ESTIMATING AND HARNESSING THE ENVIRONMENTAL BENEFIT OF FOOD WASTE REDUCTION FOR THE FOOD BANKING SYSTEM

by

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Abstract

Recent research by the National Resource Defense Council (NRDC) estimated that 40% of the food produced in the United States, or 66 billion lbs., is wasted every year. As the largest source of organic waste in landfills, the environmental impact of food waste recovery can be significant. Between 50%-85% of the food a food bank receives is diverted from a landfill. Feeding America estimates an additional 10.5 billion lbs. of food is needed to eliminate hunger in the United States. Given that food banking contributes to food waste diversion, can carbon offsets can be sold to financially support the growth of food banks?

This analysis uses the Raleigh branch of the Food Bank of Central and Eastern North Carolina as a case study to calculate a single food bank's greenhouse gas emissions and compare it to an alternate scenario where the food delivered by the food bank ends up in a landfill. Calculations based methodologies from The Climate Registry's General Reporting Protocol, the United States Environmental Protection Agency's WARM model and a self-developed geospatial network analysis model (using ArcGIS) provided the basis of the analysis. The results show that the food waste diversion saves between 3,000 - 5,600 $mTCO_2e$ in emissions, which is 1.8 to 3.2 times the operational emissions of the food bank. Every pound of food moved by the food bank saves 0.39lbs. CO_2e.

The amount of greenhouse gas savings, if monetized, could partially subsidize additional human resources, asset capacity expansions, or energy efficiency investments that could lead to long term financial and environmental savings.

While a food bank can show it has a positive environmental benefit through reduction of food waste, harnessing it financially will be difficult. Requirements for recognizing and selling a carbon offset make it difficult for any single food bank to access the carbon offset market. Active participation of umbrella organizations like Feeding America, government and corporations would be needed to investigate this potential further. Alternatively, additional market analysis can be done to identify new fundraising targets and strategies for food banks by highlighting their environmental benefits.

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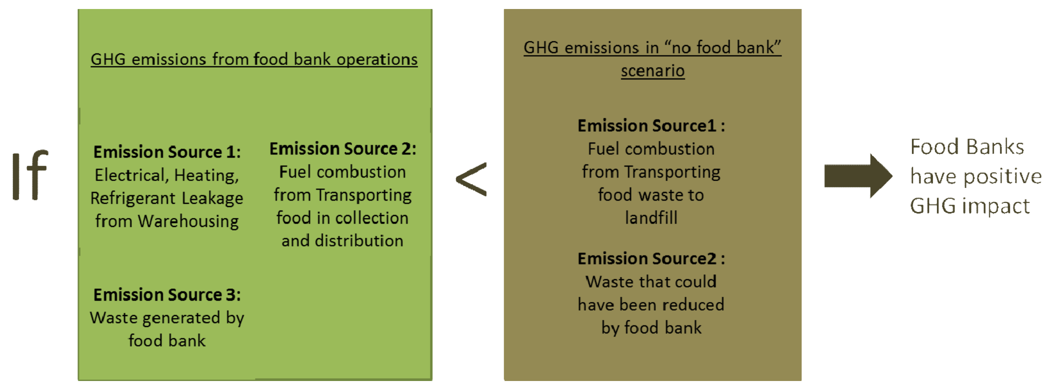
EXECUTIVE SUMMARY

Recent research by the National Resource Defense Council (NRDC) concluded that 40% of the food produced in the United States, or 66 billion pounds, is wasted every year. As the largest source of organic waste in landfills, the environmental impact of food waste recovery can be significant. Reducing all emissions from food waste is equivalent to nearly half the 2012 estimated reduction from 540 unbuilt landfill gas recovery projects in the United States. If 15% of the food waste could be recovered and re-delivered, it could mean cutting food insecurity in the United States by half.

Suppliers in the food recovery system have economic incentives to donate wholesome food. Aside from legal liabilities, they find it difficult to donate more because of the lack of asset capacity of the recipients. Food banks and food pantries, the buyers in this system, are run as non-profits and can have financial capacity constraint in asset upgrades.

My analysis shows that between 50%-85% of the food a food bank receives is diverted from a landfill. To establish the environmental impact of food banks, I compared the greenhouse gas (GHG) emissions from a food bank's operations to the GHG emissions in a "no food bank" scenario, as below.



Using the Food Bank of Central and Eastern North Carolina (FBCENC) as a case study, I find that a food bank's operations can save between 1.8 – 3.2 times its own operational emissions depending on its food sources. At a median savings of 2.5 times its own operational emissions, the food bank does have a significant net positive impact on GHG emissions reductions through its role in food waste reduction. In the context of Food Bank of Central and Eastern North Carolina, their savings of 4,360 mTCO2e is more than 10% of the current landfill emissions of the City of Raleigh. Being able to increase their capacity by 50% would reduce Raleigh's landfill emissions by 7%.

My analysis also discussed the impacts on energy use and GHG emissions as FBCENC grows. Current trends in supplier types show:

1) an increase in suppliers who are retailers and wholesalers as opposed to manufacturers;
2) an increase in fresh produce.

Both these trends will increase FBCENC's operational emissions profile disproportionately as it will involve more supplier pickup and more refrigeration.

If FBCENC is concerned about its environmental impact as it grows its capacity, it will need to:

1) source more foods from manufacturers, retailers and farmers, as opposed to government aid programs to reduce more food waste;
2) improve its energy efficiency through investing in waste reduction and solar energy to produce less emissions.

Monetizing the food bank's environmental benefit can help it grow to reduce more food waste, as well as become more energy efficient. For FBCENC, if this greenhouse gas reduction could be monetized through the carbon offset markets, it would have the ability to deliver 11,400 additional meals, increase staff headcount, or subsidize investments new assets or energy efficiency upgrades.

Many hurdles exist to achieve monetization of greenhouse gas reduction in the carbon offset markets. And this is especially so for a non-profit, non-revenue generating entity like a food bank. Developing a protocol of food waste recovery is costly and time consuming. Taking into account the need for additionality and possible leakages from the system can result in much less emission reduction being recognized for the benefit of the food bank. This analysis proposes structures that can lower some of the hurdles, but would require active participation by key funders and an umbrella organization for food banks, like Feeding America.

Aside from accessing the carbon offset market, the findings in this analysis allows for food banks to tap funding from corporations and individuals with a new message emphasizing its environmental benefit. A food bank's dual impact outcome can be a strong selling point and more market analysis should be done to identify new fundraising targets.

DEFINING THE PROBLEM

Food waste and how the food banking system can reduce emissions from food waste reduction

Recent research by National Resource Defense Council (NRDC) highlights the astounding amount of food wastage in the United States. 40% of the food produced is wasted, amounting to about 66 billion pounds of food a year.[1,2] According to the EPA, food waste is now the single largest source of waste entering landfills[3]. Post recycling, food waste contributes to 21.3% of the total municipal solid waste entering landfills.[4] As the largest organic component of the landfill, food waste can be considered the largest source of methane production in the landfill.

Food waste recovery's environmental impact can be significant. Based on calculations using EPA's WARM model[5], if all 66 billion pounds of food is diverted from the landfill, there is a potential to save 6 MMTCE in emissions (*see Appendix 1 - Calculating Food Waste Recovery's Impact on Landfill Emissions*). This is nearly half of the savings from 540 unbuilt landfill gas recovery projects identified by EPA[6].

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[1] Gunders, Dana. (2012). *Wasted: How America Is Losing Up to 40 Percent of Its Food from Farm to Fork to Landfill* (Publication: Issue Paper 12-06-B). San Francisco, CA: Natural Resources Defense Council.

[2] Calculations of food wasted in pounds is based on the corresponding interview on National Public Radio with Ms. Dana Gunders on 21 September 2012. It is quoted that 33 million tons of food is wasted. This corresponds to 66 billion lbs (1 short ton = 2000 lbs). The interview "The Ugly Truth About Food Waste in America" can be accessed here: http://www.npr.org/2012/09/21/161551772/the-ugly-truth-about-food-waste-in-america

[3] United States Environmental Protection Agency. (2013). *Reducing Food Waste for Businesses.* Retrieved 3 December 2013 from: http://www.epa.gov/foodrecovery/

[4] United States Environmental Protection Agency. (2013). *Municipal Solid Waste in the United States – 2011 Facts and Figures*. Retrieved 29th August 2013 from: http://www.epa.gov/osw/nonhaz/municipal/pubs/MSWcharacterization_fnl_060713_2_rpt.pdf

[5] United States Environmental Protection Agency. (2012). *Waste Reduction Model (WARM) Version 12 (Feb 2012)*. Retrieved 29th August 2013 from: http://epa.gov/epawaste/conserve/tools/warm/Warm_Form.html

[6] United States Environmental Protection Agency. (2012). *Landfill Methane Outreach Program, Energy Projects and Candidate Landfills*. Retrieved on 1 June 2013 from: http://www.epa.gov/lmop/projects-candidates/index.html.

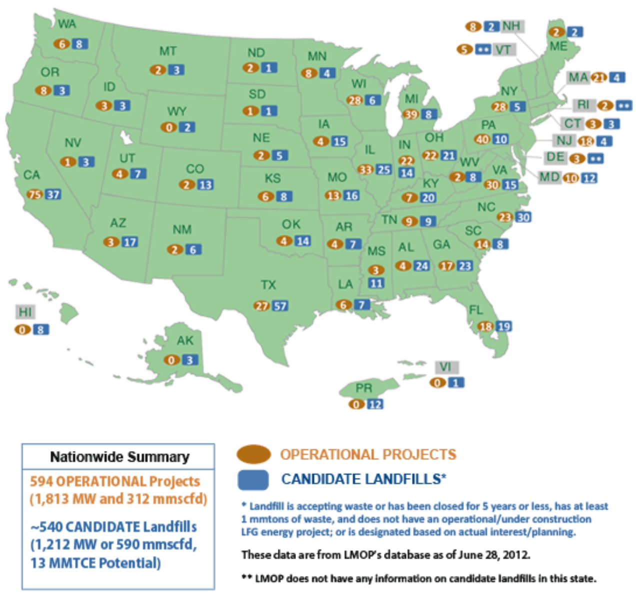

Figure 1: Greenhouse gas emission reduction potential of landfill gas recovery in the United States. Source: Landfill Methane Outreach Program, EPA, http://www.epa.gov/lmop/projects-candidates/index.html, data as of June 28, 2012.

Economically, wasted food also represents about $145 billion of lost production cost. Socially, 15% of the wasted food, if saved, could feed 25 million hungry Americans.[7]

In its effort to reduce the economic, environmental and social impacts of food waste, the EPA has introduced a food waste recovery hierarchy to food service providers. What it recommends is in line with the waste hierarchy for other waste products: Reduce, Reuse, Recycle, in that order. In the food waste context, I can roughly map the Food Guide's recommendation as follows:

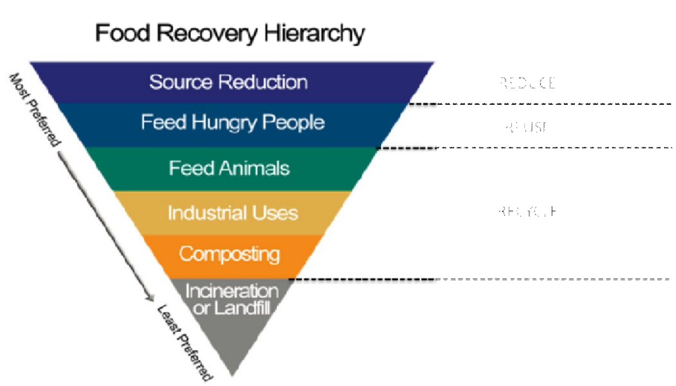

Figure 2: Mapping the food waste recovery hierarchy to the generic waste hierarchy. Source: EPA, Food Recovery Challenge, retrieved from: http://www.epa.gov/smm/foodrecovery/ and Xinying Tok.

[7] Gunders, Dana.

Based on this hierarchy, EPA recognizes donations to food bank as a preferred method of food waste diversion. Although it is the preferred method of food waste reduction, a lot less food waste is recovered for that purpose as opposed to recovered as animal feed or composting. The Food Waste Reduction Alliance (FWRA), a cross-sector industry initiative led by the Grocery Manufacturers Association (GMA), the Food Marketing Institute (FMI) and the National Restaurant Association (NRA), have pulled together data submitted voluntarily by their members on where food waste ends up[8].

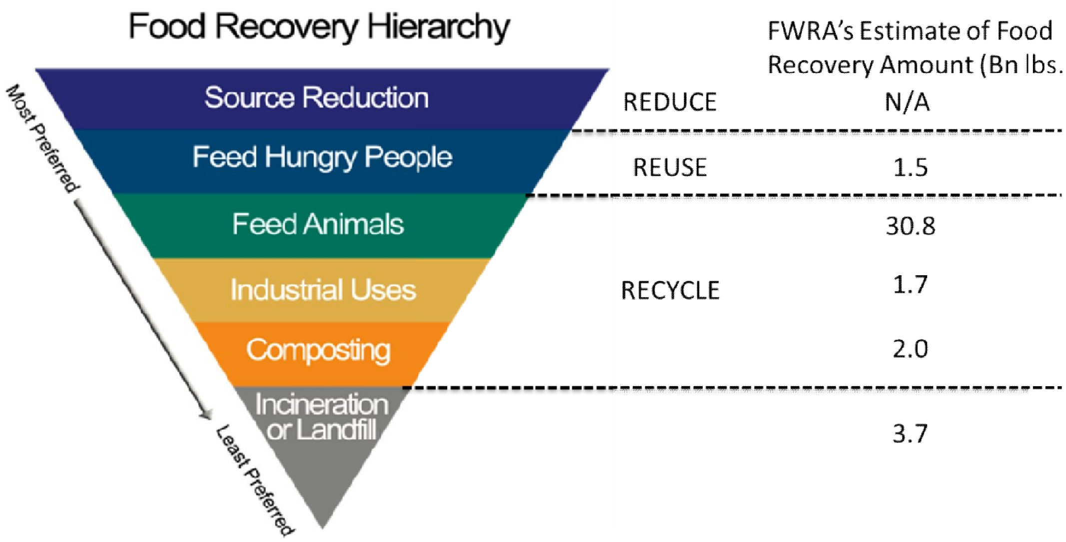

Figure 3: Food waste recovery methods used in manufacturing and retailing. Source: BSR, "Analysis of U.S. Food Waste Among Food Manufacturers, Retailers, and Wholesalers, prepared for FWRA", April 2013.

Of all the sources of food waste in the food supply chain – farm harvest, manufacturing (including both processing and distribution), retail, food service and households - farm harvest, manufacturing and retail have the highest potential for redistribution to the hungry. Economic incentives exist to encourage these suppliers of recoverable foods. These include reduction of waste haulage fees as well as tax incentives to donate food. At an estimated landfill tipping fee of $25/ton, the food waste diversion (not necessarily to feed the hungry) has saved the food manufacturing/retail/wholesale industry close to $555 million[9]. In addition, the tax code allows for corporations who donate wholesome food to get

[8] The 26 survey participants were members of FMI and GMA, representing 17% of revenue of the US food manufacturing industry and 30% of revenue of the US food retail and wholesale industry. The reported figures were extrapolated from the survey response.
[9] BSR. (2013). *Analysis of U.S. Food Waste Among Food Manufacturers, Retailers, and Wholesalers, prepared for FWRA*. Food Waste Reduction Alliance.

enhanced tax deductions. These deductions are the lesser of 1/2 of the Gross Profit or Basis Cost of the food. This can amount to slightly more than 10% of the donated food value.[10]

If there exist incentives for the suppliers of recoverable food, is there similar financial support for buyers of recoverable food? In particular, for food banks, which are run as charitable organizations, how do they build their financial capacity for growth? For every additional one million pound donated, the food banking system will need to have the human resource and asset capacity to handle the additional food.

Feeding America, the largest United States based food recovery organization network, recovers and distributes on average 549 million pounds of fresh produce annually. Including manufactured products, the total is 3.4billion pounds[11]. This is about 5% of the total amount of food wasted. Even with this massive operations, Feeding America estimates there are still 50 million Americans who are food insecure, who need 8.2 billion meals annually to live marginally healthy lives[12]. At an estimated 1.28lbs per meal provided by food banks, that is roughly 10.5 billion pounds of food[13]. This means the food banking system would need to expand its capacity by 3 times to be able to achieve its mission of eliminating hunger. If successful, the food banking system can contribute to eliminating 16% of the current carbon emissions from food waste entering landfills.

Food banks are largely run on private donations and charitable grants. The largest part of the donations they receive are in the form of food donations (*See Appendix 2 - Example of a food bank's budget*). Grant donations are spent on specified programs, leaving very little to build asset capacity and a robust organization in the long term. In fact, according to the FWRA, one of the top obstacles to increasing food donations from manufacturers and retailers/wholesalers is the lack of space and refrigeration at food banks as well as the lack of refrigerated transportation to food banks. Both of these represent asset enhancements that need to be funded in order to significantly increase the receiving and delivery capacity of food banks.

Given that food waste is a key contributor to the methane emissions from landfills, and food banking contributes to waste diversion, can we imagine the possibility where carbon offsets can be sold to financially support the capacity expansion of food banks, just like carbon offsets are sold to financially support landfill gas recovery projects? Can carbon offset sales have a significant impact on the financial sustainability of food banks?

This study seeks to understand how the food banking system can leverage its resulting environmental benefits further its mission to eliminate hunger.

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[10] Food Donation Connection. *United States Tax Benefits.* Retrieved on 29th August 2013 from: http://www.foodtodonate.com/Fdcmain/TaxBenefits.aspx

[11] Feeding America. (2012). *2012 Annual Report*. Chicago, IL: Feeding America.

[12] Feeding America. (2011). [Map Illustration of Food Insecurity in the United States]. *Map the Meal Gap*. Retrieved on 3 Dec 2013 from: http://feedingamerica.org/hunger-in-america/hunger-studies/map-the-meal-gap.aspx

[13] Mathematica Policy Research, Inc. (1999). *Food Stamp Participants' Food Security and Nutrient Availability* (MPR Reference No.: 8243-140). Princeton, NJ: Mathematica Policy Research, Inc.

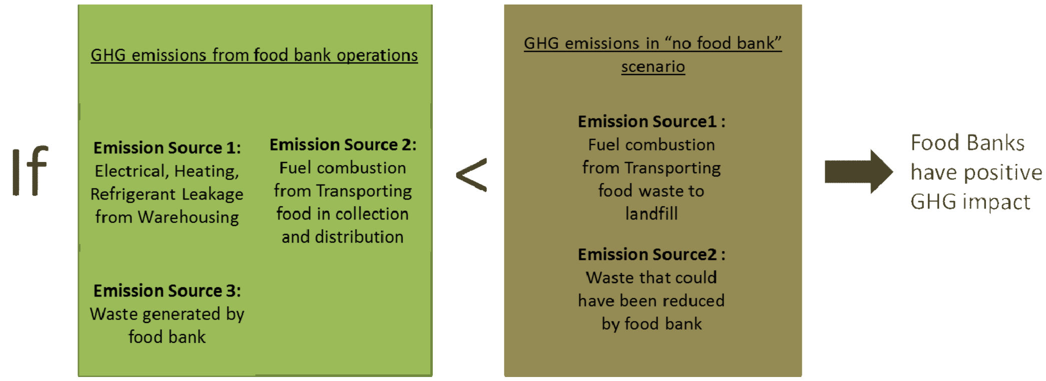
The study begins by characterizing the greenhouse gas emissions of a case-study food bank. I then seek to test the following hypotheses on why carbon offsets for food waste diversion have yet to be recognized under any of the carbon offset standards.

I posit that it is possible that:

1) There are no net GHG savings in the whole operations of a food bank; or that
2) The GHG savings are not significant even if monetized; or that
3) There are significant GHG savings but it is technically difficult to meet the requirements for the carbon offset markets.

FINDING 1: A FOOD BANK'S OPERATIONS REDUCES GHG EMISSIONS

My investigation begins with first establishing if there are any GHG savings in the operations of a food bank when compared to a "no food bank" scenario. The analysis logic is as follows:



Quantifying a food bank's GHG impact

GHG emissions of food bank's operations

In order to calculate food bank GHG emissions, I take an approach similar to a supply chain analysis of the recoverable food as the product that is being consumed. In this stylized scenario, the recoverable food is the raw material, the food bank is analogous to a manufacturing facility and I include the distribution network to the food bank's partner agencies who act like retail channels and interface directly with its consumers – the food insecure population.

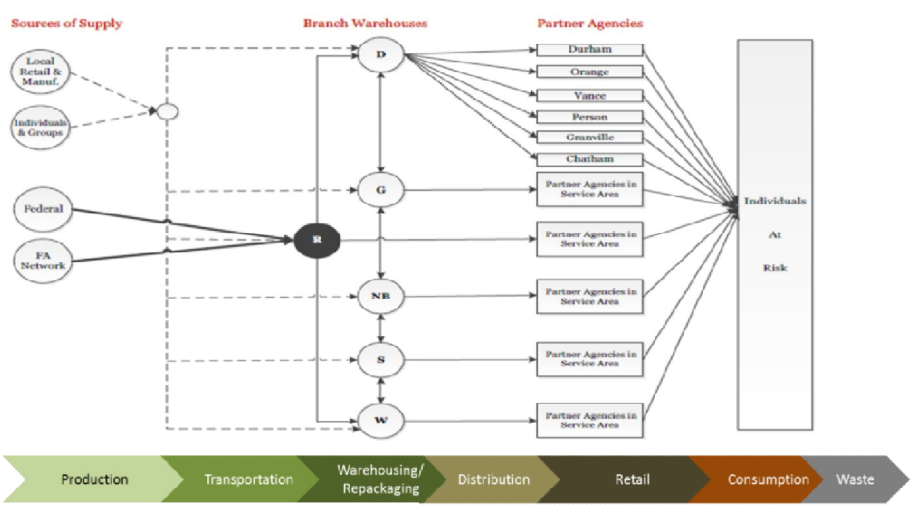


Figure 4: The product flow of a food bank network mapped to the phases of a life cycle analysis. Source: Davis, Jiang and Terry, May 2013.[14] and Xinying Tok.

Typically, a food commodity that would have been discarded at a retail store, such as Food Lion, would be unshelved, collected and packed by the retail store staff. On a scheduled pickup date, the food bank's trucks will arrive and pickup the pallets of food that have been accumulated since the last pickup date. The food is trucked back to one of the food bank's branches (R). At the warehouse, the food is sorted and assessed for quality in meeting food safety standards. Food that does not meet the quality standards (e.g. an unsealed whole baguette) will be thrown out as waste.

Some of the eligible food will be tagged, packed and set aside for re-delivery to the partner agencies within the food bank's service area. Others will be shelved to be picked up by partner agencies that come to the warehouse with their own transportation to pick up the food.

At the partner agencies' location, the food is further processed (i.e. cooked, repacked). Individuals at risk either receive this food by coming to the partner agencies' soup kitchens, or like in the case of school lunch programs, the food is again delivered to a school.

In order to reach more partners without increasing the footprint of a food bank, food banks might linkup partner agencies directly with a retail store within close proximity. This shortens the delivery process and also helps to reduce emissions impact.

Based on this stylized scenario, I compile a greenhouse gas inventory of relevant energy and material inputs and outputs of a specific food bank. From there, I evaluate the environmental impacts of the existence of a food bank.

<u>A case study partner that is at once typical and unique</u>

The universe of food banking is diverse and the operations can be rather complicated. Based on the database of Feeding America's 200 food banks[15], a foodbank can provide food as well as non-food distributions, operate just an on-site shopping service for partner agencies as well as a mobile pantry or a production kitchen and a community garden or a combination of some or all of these. The diversity of operation type and the resulting implications in terms carbon emissions can have on an organization make it difficult to collect similar information across many different food banks[16]. For the purpose of gaining a preliminary understanding of the emissions from food banking operations, I have chosen to focus on one particular Feeding America food bank in North Carolina – Food Bank of Central and Eastern North Carolina (FBCENC).

[14] Davis, L.B., Jiang, S. and Terry, J. (2013). *Empirical modeling of in-kind donations for a non-profit hunger relief organization*. Paper presented at Industry Studies Association Annual Conference. Kansas City, MO.
[15] Feeding America. (2013). *Our Food Bank Network*. Retrieved 4 December 2013 from: http://feedingamerica.org/how-we-fight-hunger/our-food-bank-network.aspx
[16] Prior to a case study approach, this project attempted to survey food banks to obtain a high level overview of greenhouse gas emissions in a food bank. However, only 3out of 60 food banks responded to a repeatedly survey requests. All 3 food banks had varying levels of details in the data provided, making it difficult to aggregate or make meaningful comparisons across the information provided.

FBCENC was chosen as a target organization of analysis for its importance in delivering food to the food insecure. The state of North Carolina is one of the 10 states in the United States that have a higher than national average of household food insecurity rates[17]. FBCENC serves the 5 counties in North Carolina with the highest rates of food insecurity[18].

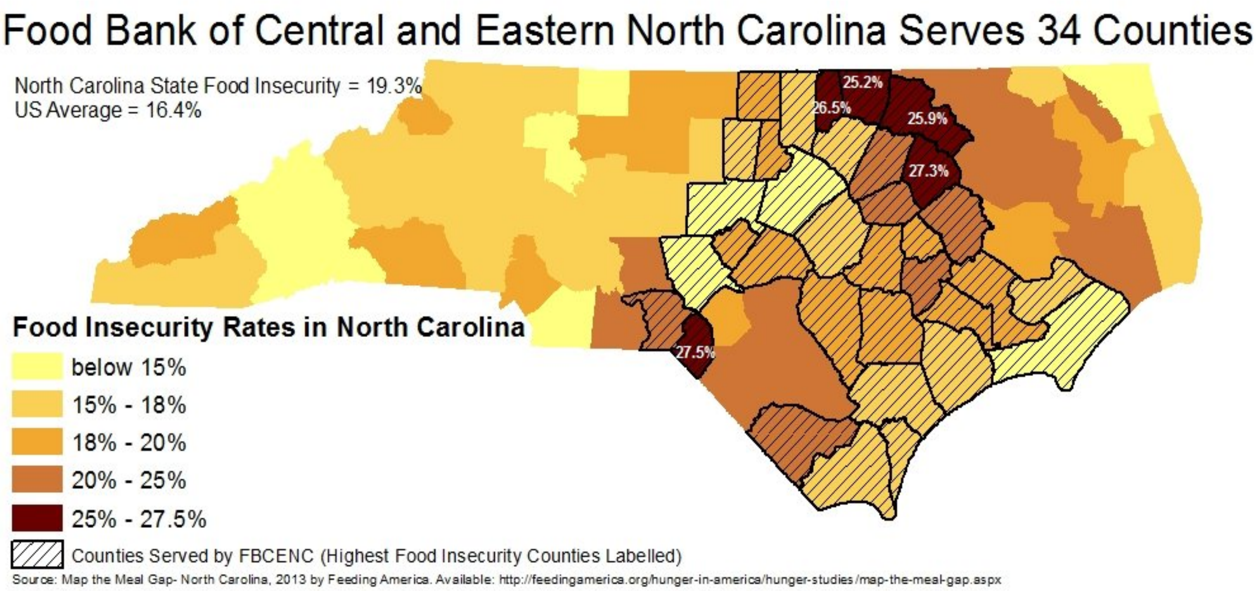


Figure 5: North Carolina counties served by FBCENC by food insecurity rates. Source: Data based on Feeding America's Map the Meal Gap – North Carolina Food Insecurity by County in 2011.

At FBCENC, 80% of its food distribution is delivered to partners by their trucks or picked up from their warehouses when partner agencies come 'shop' for food[19]. Although FBCENC's operations does not cover the range of services that the food banking universe has, it allows for a simpler analysis which can serve as a building block for understanding other food bank's activities. A food bank that focuses on on-site shopping services is the typical model for the major food banks within the Feeding America network.

On the other hand, the size of FBCENC is atypical. Serving 34 counties and distributing 45 million pounds of food in 2011, FBCENC ranks in the top 15 food banks (out of 200) within Feeding America's network based on amount of food distributed annually. FBCENC's distribution capacity has risen quickly over the

[17] Feeding America. (2011). [Map Illustration of Food Insecurity in the United States]. *Map the Meal Gap*. Retrieved 20th November 2013 from: http://feedingamerica.org/hunger-in-america/hunger-facts/hunger-and-poverty-statistics.aspx.

[18] See Appendix 3 - Feeding America's Map the Meal Gap Project for a summarized methodology on estimating food insecurity.

[19] FBCENC. Interview with staff from Product and Inventory Control Department on 31 May 2013. Data for March 2013 was provided after interview.

years. In the last 2 years, its distribution capacity has grown 10% year on year[20]. Its ability to achieve its growth and success has been based on the partnerships it has built both with donors (food, in-kind, volunteer) as well as partnership agencies that aid in efficient delivery of the food it distributes.

Being able to assess the activities of a food bank like FBCENC can gives us insight into:

1) What the GHG emissions from the operations of a food bank are;
2) Whether there are GHG emissions savings from the operations of a food bank;
3) How these GHG emissions savings can be leveraged to improve the food bank's capacity.

Various board and staff members of the Raleigh branch of FBCENC were interviewed, archival records were retrieved and publicly available documents reviewed as part of the case study.

The GHG Inventory for FBCENC

Boundaries of FBCENC's analysis

In this GHG emissions inventory of FBCENC, the boundaries of analysis are based largely on the concept of operational control. Emissions that cannot be controlled by the food bank are left out of the inventory. In general, these are activities after the distribution phase. The figure below summarizes the key emissions sources from the phases that have been left out of the inventory.

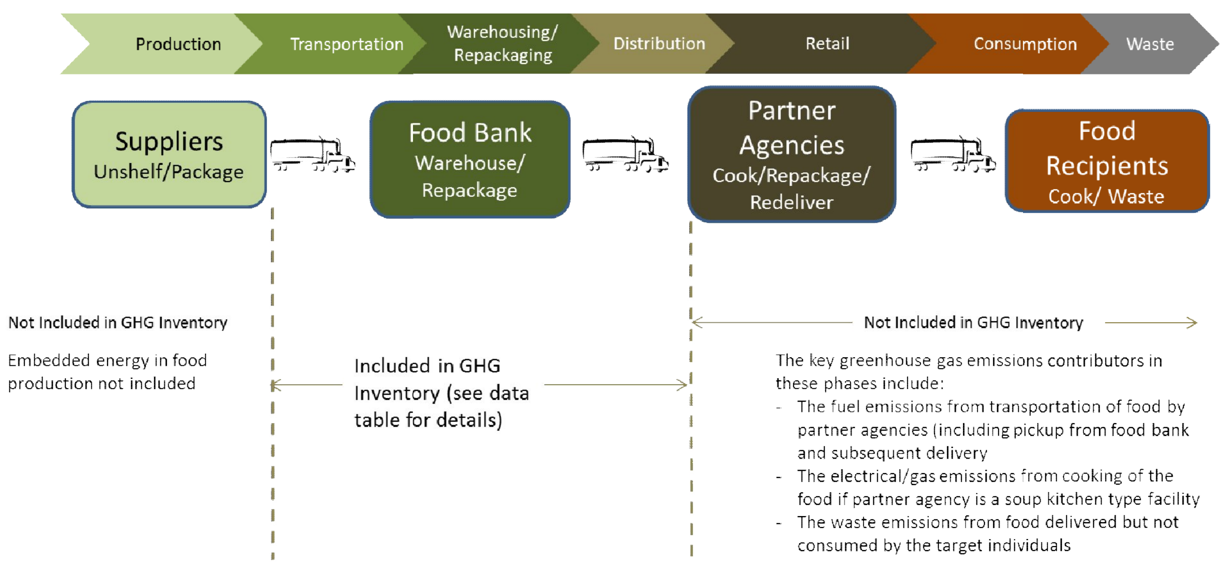


Figure 6: Boundaries of analysis in GHG emissions inventory for FBCENC

[20] FBCENC's distribution for FY 2011 and FY 2012 obtained from its 2012 Annual Report. Distribution for FY 2013 obtained from its website, retrieved 3 December 2013: http://www.foodbankcenc.org/site/PageServer?pagename=about_mission

No specific data has been collected on the production, retail, consumption and waste phases because these are outside the operational control of the food bank. However a brief analysis on the possible impacts on the overall outcome of analysis is provided in Appendix 4.

The Raleigh branch

FBCENC consists of 6 separate branches servicing 34 counties, each with its own warehouse and trucking resources. The Raleigh branch warehouse is the largest of all its facilities and it is the only one that is owned by the organization. Aside from being a branch in the FBCENC network, it also acts as a regional distribution warehouse. In fiscal year (FY) 2011 – 2012, 24.5 million pounds of the total 45 million pounds FBCENC distributed came through the Raleigh branch.

This GHG Inventory only covers Raleigh branch.

GHG Inventory Data

The table below summarizes the type of data collected from FBCENC to create its GHG inventory. Appendix 5 provides full list of the individual data and the departments within FBCENC which assisted with the data collection.

Relevant Life Cycle Phase	Data Type	Emission Source Type
Warehouseing/Re-Packaging	Stationary combustion of natural gas to produce heat and hot water using equipment in a fixed location.	Scope 1: Direct Emissions from Stationary Combustion
Warehouseing/Re-Packaging	Fugitive emissions that are unintentional releases from refrigeration.	Scope 1: Direct Emissions from Fugitive Emissions
Transportation / Distribution	Mobile combustion of fuels in fleet transportation sources such as trucks used. The fleet operates on diesel fuel only.	Scope 1: Direct Emissions from Mobile Combustion
Warehouseing/Re-Packaging	Purchased Electricity	Scope 2: Indirect Emissions from Electricity Use
Warehouseing/Re-Packaging	Waste Disposal of FBCENC	Scope 3: Other Indirect Emissions

Table 1: High level summary of data used for GHG Inventory.

GHG Inventory Summary

The table below summarizes the GHG emissions of FBCENC for FY 2011-2012, based on the calculation methodologies of The Climate Registry's Global Reporting Protocol. The full report is provided in Appendix6.

Emissions Type	CO_2e (Metric Tons)	% of reported emissions
Scope 1: Direct		
Vehicle fuel combustion (100% diesel)	632	36.4%
Natural gas for heating	28	1.6%
Refrigerant leakage in facilities	169	9.7%
Refrigerant leakage in vehicles[a]	67	3.8%
Scope 2: Indirect		
Purchased Electricity	257	14.8%
Scope 3: Other indirect		
Waste[b]	581	33.5%
Total emissions	1,734	

[a] Using the screening method allowed in The Climate Registry's calculation methods, refrigeration emissions from the 5 refrigerated trailer units used by Raleigh branch is less than 5% of total emissions and hence the higher of the screening method estimates are used. For estimation details, please see Appendix 6B.

[b] The food bank generated 1.6million lbs of waste in FY 2011-2012. Less than 50% of this waste is food that was received but could not be distributed. While not all the waste is food scraps, the GHG emissions were modelled as if all the waste were food scraps as no waste audit was conducted on site. This will likely result in a higher amount of GHG emissions from waste.

Table 2: GHG Inventory Summary Report, Xinying Tok and FBCENC.

GHG Emissions of the alternate "no food-bank" scenario

To understand how the food bank's existence impacts the total GHG emissions from food waste that it saves, I compare it to a scenario where the food bank does not exist. Here, the recoverable food has to be trucked from its source to a landfill. At the landfill, the decomposition of the food will contribute methane emissions, estimated based on EPA's WARM model.

Estimating GHG emissions from transportation to landfill

Instead of the transportation involved where FBCENC collects the foods from its donors and transports it to the warehouses and its partner agencies, there is now transportation of the same foods from the donors to the nearest landfill.

My assumptions in this scenario include:

- Food that was donated by each of the donors in my analysis would have otherwise gone to the landfill.
- Each retailer or local farm will truck food individually to the landfill itself on the same schedule as it would have been picked up by FBCENC. This means that if FBCENC collects from the specific retailer twice in a week, it is assumed the retailer would have trucked to the landfill twice in a week. This also means that although there are, for instance, multiple Food Lion stores that FBCENC might pick up from on the same day, the Food Lion stores all will individually truck their waste to the landfill and not consolidate amongst the stores.

Appendix 5 provides details on the data collected for the alternate “no food bank” scenario.

In order to estimate the trucking distances and the corresponding emissions to the landfills, daily pickup addresses of donors were obtained for 2 weeks in March 2013. According to the FBCENC’s Transportation Department, the schedule of pickups and deliveries for the Raleigh branch repeats every 2 weeks. This analysis timeframe allows us to capture all of the regularly scheduled pickup points and estimate each pickup point’s distance to the nearest landfill.

These pickup points were analyzed together with a list of 161 landfill locations in North Carolina. Using the Network Analyst tool in ArcGIS, the individual travel distances by each donor to the closest landfill was calculated and summed.

The next two maps show the locations of suppliers, their nearest landfill and the routes generated by the Network Analyst – Closest Facility tool. The GIS methods used are summarized in Appendix 7.

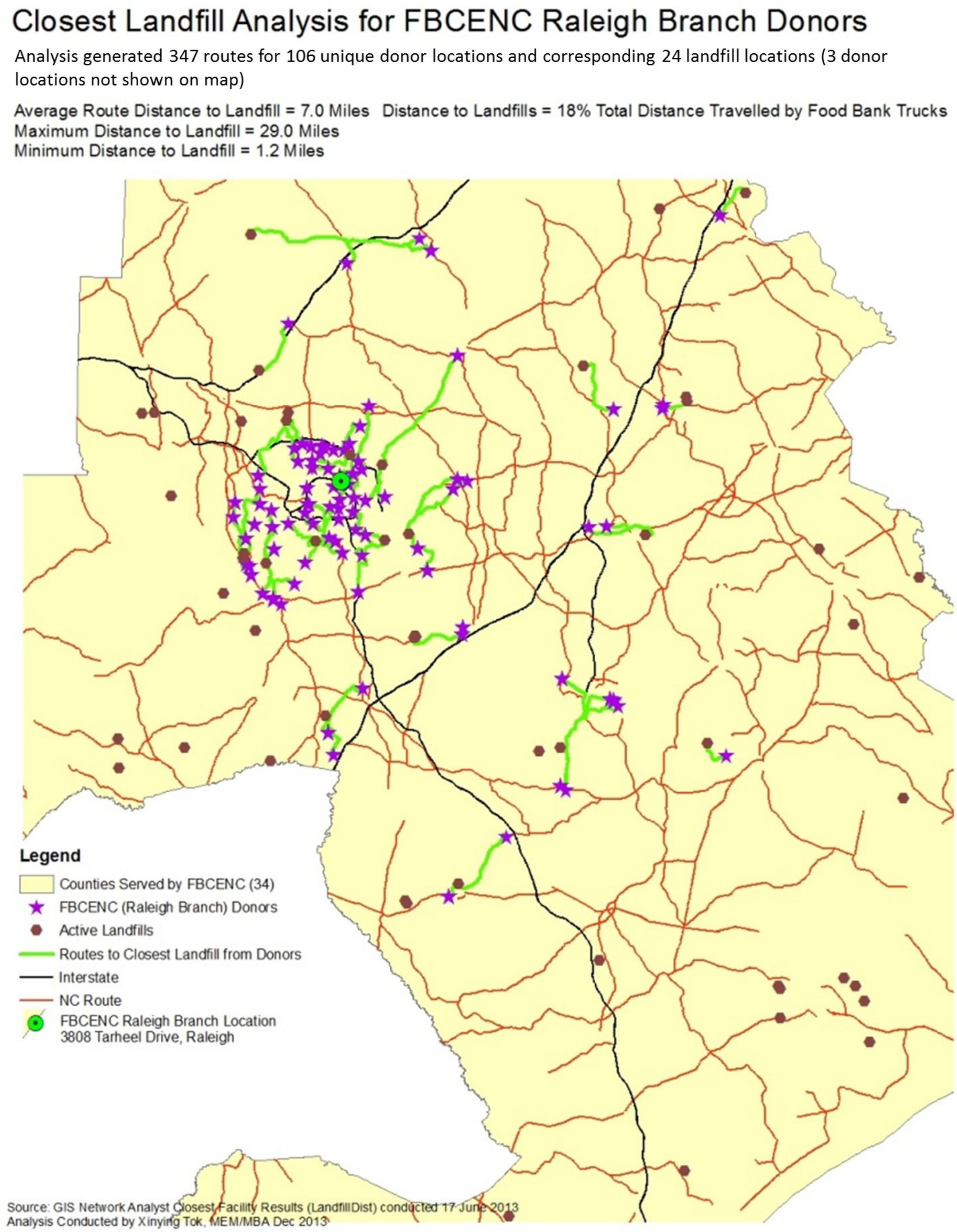


Figure 7: GIS results showing the nearest landfills and routes of 103 out of 106 suppliers to FBCENC Raleigh branch.

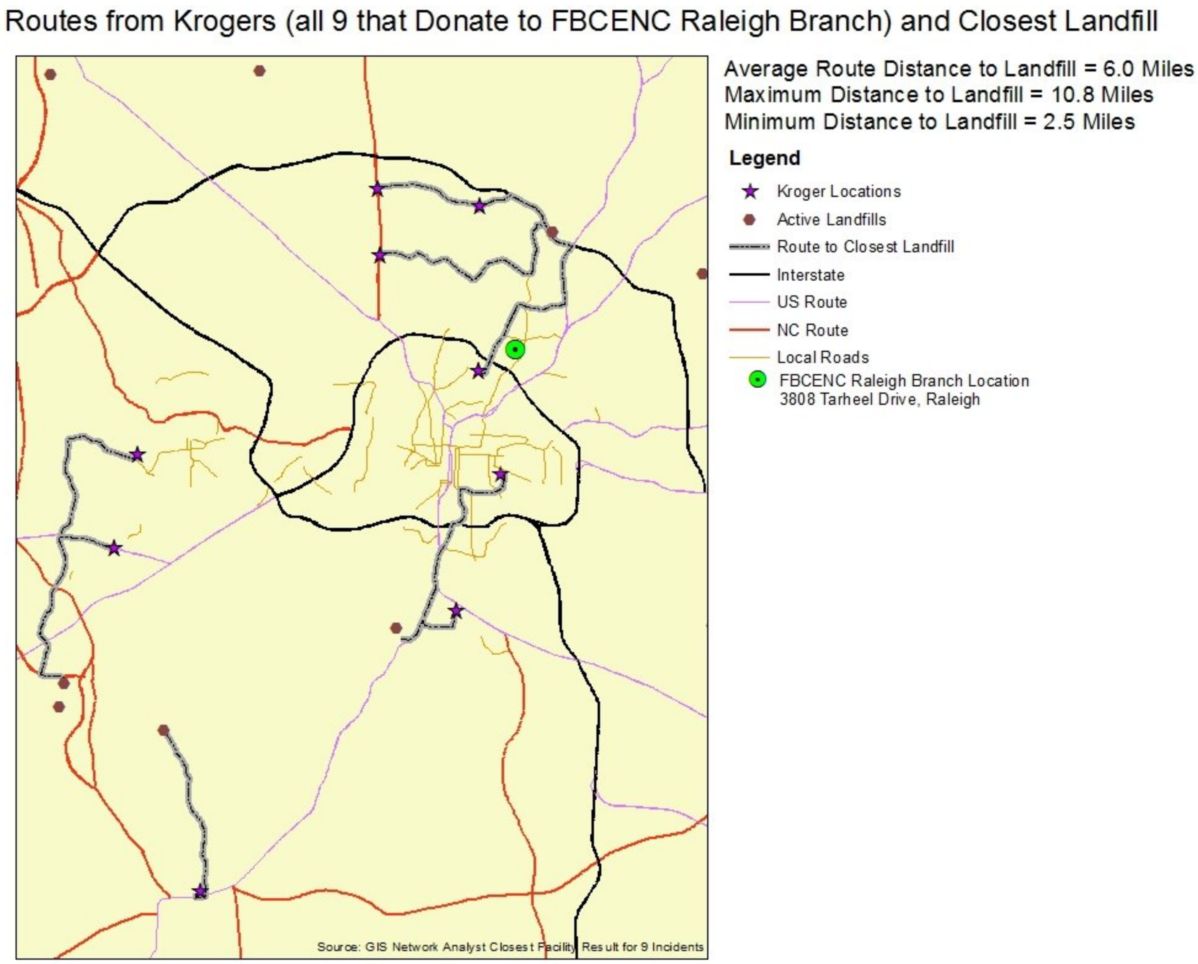


Figure 8: An example of the GIS analysis results, focusing on donations received from Kroger locations.

Based on the data and GIS analysis for the trucking requirements between March 2 – 15 2013, it is estimated that the alternate scenario will incur 18% of the total vehicular emissions the FBCENC incurs.

Transportation Route Estimations based on data from Mar 2 - Mar 15 2013	miles
Total Distance Travelled by Food Bank Trucks	12,714
Total estimated trucking distance landfills	2,284
% of trucking emissions	0.18

Table 3: Results of GIS Analysis used to estimate distance travelled from suppliers to nearest landfill.

Estimating GHG emissions from food waste that would have been reduced

Not all the food that moves through the food bank would have ended up in the landfill, i.e. not all the food can be considered “recoverable food”. Food banks in the Feeding America network have 5 general sources of food – Federal Commodities, Manufactured Foods, Purchasing, Retail, Produce.

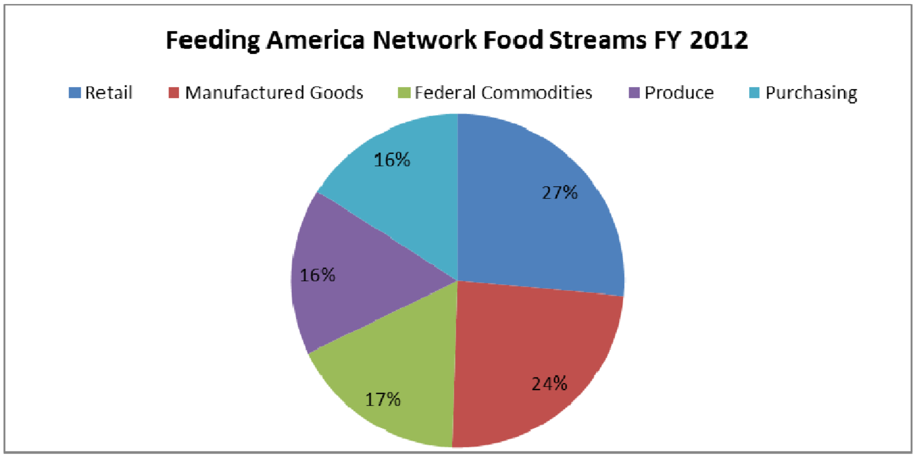


Figure 9: Five channels of food sources for Feeding America's network in 2012. Source: Feeding America, Supply Chain Group.

Manufacturing and retail sources are partnerships that Feeding America has at a national level that allows food banks within their network to access food from manufacturers and chain retail/grocery stores within their localities. The food received from these sources are usually manufacturing rejects (excess runs, packaging errors) or shelf stable goods that are going off the shelf.

Federal commodities comes from The Emergency Food Assistance Program (TEFAP) program (TEFAP) where USDA funds appropriated by Congress is used to purchase food and distribute it through food banks and TEFAP recognized partners to those in need.

Produce are sourced from farms that were not harvested or bought by wholesalers/retailers.

Foods that are classified purchasing are those that food banks purchased at market price directly from stores to supplement the food they have received.

Feeding America estimates the following proportion of each food source that is considered diverted from landfills[21]:

a. Federal commodities: 0% diversion
b. Manufactured foods[22]: 100% diversion
c. Purchasing[23]: 0% diversion
d. Produce[24]: 50% diversion
e. Retail: 100% diversion

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[21] Feeding America. Interview with staff from Supply Chain Group on 13 June 2013.

[22] The assumption here is that, even for shelf stable products, food is donated when they are close to use-by dates or excess runs during the manufacturing process.

[23] These are bought by food banks at open market at market price and not excess.

[24] A lot of fresh produce that is not sold typically would have gone to animal feed and or composting and thus not necessarily landfilled. This really depends on where food banks are sourcing produce from. According to FBCENC, the food they source direct from local farmers would have been destined for the landfill.

Federal commodities and purchasing streams are deemed to be 0% diversion because the food is purchase outright and would likely have been purchased by consumers otherwise. It is also expected that some produce would have gone to animal feed if not purchased and hence a 50% diversion rate is applied as an assumption.

Based on FBCENC's food sources, I can estimate the GHG savings impact of the food bank's delivery of recoverable food. The GHG emissions saved is calculated using EPA's WARM model.

In estimating the amount of recoverable food that comes through FBCENC, I used the following breakdown of sources of foods that came through FBCENC[25].

a. Federal commodities: 12%
b. Manufactured foods: 20%
c. Purchasing: 2%
d. Produce: 30%
e. Retail: 36%

According to FBCENC, the farmers that donate local produce do not send their undonated food to animal farms or composting companies. Much more likely, the produce would have been left on the fields to decompose. As such, they believe it is safe to assume a 100% landfill diversion for the produce category of foods they receive.

Given this divergence with Feeding America's assumptions, I calculated 3 separate emissions scenarios based on 3 sets of assumptions as described below.

Food category	Feeding America Assumptions	FBCENC Assumptions	Zero savings from Produce
Federal commodities	0% landfill diversion	0% landfill diversion	0% landfill diversion
Manufactured foods	100% landfill diversion	100% landfill diversion	100% landfill diversion
Purchasing	0% landfill diversion	0% landfill diversion	0% landfill diversion
Produce	50% landfill diversion	100% landfill diversion	0% landfill diversion
Retail	100% landfill diversion	100% landfill diversion	100% landfill diversion

Table 4: Different savings factor of foods received by food bank

GHG Emissions Saved

The Waste Reduction Model (WARM) model was created by the EPA to "help solid waste planners track and voluntarily report greenhouse gas emissions reductions and energy savings from different waste management practices"[26]. It allows users to input the baseline and alternative scenarios for comparison. Input is based on short tons (2,000 lbs = 1 short ton).

[25] FBCENC. Interview with staff of Operations Department on 31 May 2013. Data provided for FY 2011-2012 after interview.
[26] The online version (updated Feb 2012) of the WARM model is being used. This is available at http://epa.gov/epawaste/conserve/tools/warm/Warm_Form.html

For food scraps, WARM does not allow for any source reduction or "recycling" in its alternative scenarios. It only allows for composting, landfill or incineration. As such, I will use the WARM model[27] to estimate the GHG emissions in $mTCO_2E$ for the amount of food FBCENC had saved, had it gone to the landfill.

Emissions saved from food waste diversion

	%	lbs	Feeding America's Diversion Rates	FBCENC's Diversion Rates	0% Savings from Produce
Total food delivered (Raleigh)		24,465,526			
Federal Commodities	12%	2,935,863	0%	0%	0%
Manufactured Goods	20%	4,893,105	100%	100%	100%
Retail	36%	8,807,589	100%	100%	100%
Produce	30%	7,339,658	50%	100%	0%
Purchased	2%	489,311	0%	0%	0%
Total food saved (lbs)			17,370,523	21,040,352	13,700,695
Total food saved (short tons)			8,685	10,520	6,850
GHG emissions saved ($mTCO_2e$)			5,979	7,242	4,716

Table 5: Emissions saved from food waste reduction of FBCENC Raleigh branch

FY 2011-2012, the Raleigh branch moved 24.5 million pounds of food. Based on the food source breakdown, 17.4 million pounds can be considered recoverable food that their operations saved from the landfill based on Feeding America's assumptions.

Total GHG Emissions in Alternate Scenario

Including both the transportation and waste emissions, the GHG emissions in the alternate scenario ranges between 4,829 and 7,355 $mTCO_2e$, 2.8-4.3 times the emissions from the food bank's operations.

Emissions Type	Feeding America's Diversion Rates CO_2e (Metric Tons)	FBCENC's Diversion Rates CO_2e (Metric Tons)	0% Emissions Savings from Produce Diversion Rates CO_2e (Metric Tons)
Scope 1: Direct Vehicle fuel combustion (100% diesel) - 18% of total FBCENC fuel emissions	113	113	113
Scope 2: Indirect NA			
Scope 3: Other indirect Waste	5,979	7,242	4,716
Total emissions	6,092	7,355	4,829

Table 6: GHG Emissions in "no food bank" scenario.

[27] A brief description of the WARM model's methodologies and 2 key assumptions for landfill gas recovery and waste transportation is provided in Appendix 6D .

Understanding the GHG emissions data

FBCENC's operations result in net emissions reduction

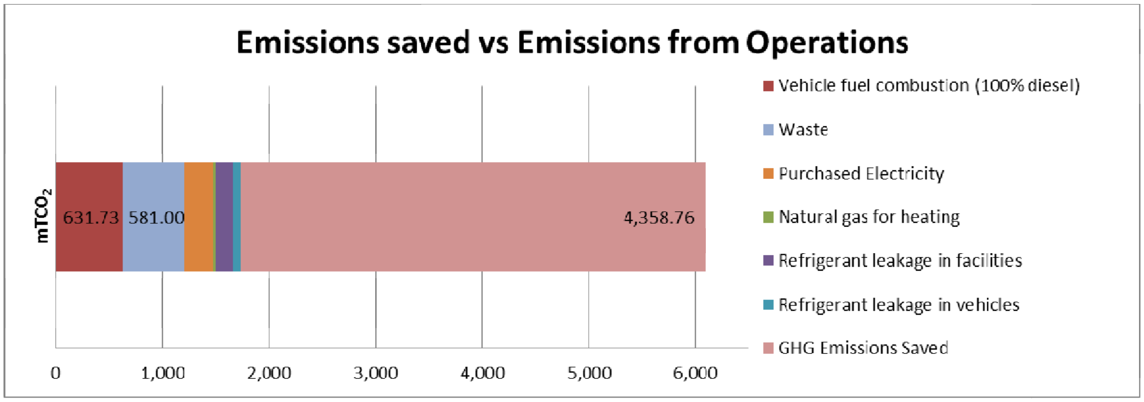

Figure 10: FBCENC operational emissions is much lower than its emissions savings from food waste diversion.

Using the scenario of Feeding America's diversion rate, I show that FBCENC's Raleigh branch's operations result in a net emissions reduction of about 2.5x its own emissions. Every pound of food saved by the food bank resulted in a 0.39lb CO_2e saved.

In this analysis, the emissions reductions assume the eaten food does not have any future waste emissions. Underlying this assumption is the capacity of local sewage and wastewater facilities to collect waste gases for flaring or energy recovery.

On the other hand, this analysis has yet to include the embedded energy in food's life cycle prior to consumption – agriculture production, harvest, handling, storage, processing and distribution. According to a FAO report, the total carbon footprint of the food wastage that occurs in North America is 900kg CO_2 eq per capita[28]. Expressed in terms of the estimated tonnage of food waste, each pound of food wastage has an embedded carbon footprint of roughly 9.3 lb CO_2 eq. About 60% of this carbon footprint is prior to the consumption phase, i.e wasted food that is potentially recoverable by the food banking system has an embedded carbon footprint equivalent to 6 times its own weight.

Can FBCENC be more energy efficient?

As I analyze the results for this single branch , single year analysis of FBCENC, what stands out as the highest contributors are transportation and waste emissions.

[28] Food and Agriculture Organization of the United Nations. (2013). *Food Wastage Footprint: Impacts on Natural Resources.* Geneva:FAO.

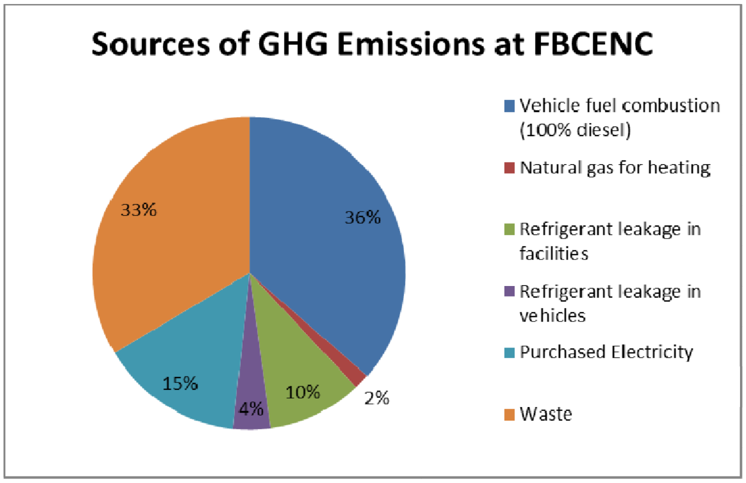

Figure 11:FBCENC's emission sources FY 2011-2012.

This seems consistent with another GHG emissions inventory that was conducted for the Contra Costa Food Bank in California in 2012, one of the very few publicly available GHG emissions inventory completed[29].

Emissions Types	CO_2e (Metric Tons)	% Emissions
Scope 1: Direct Vehicle Fuel Combustion Refrigerant Leakage in Facilities Refrigerant Leakage in Vehicles	296 2	51.3% 0.3%
Scope 2: Indirect Purchased Electricity	37	6.4%
Scope 3: Other Indirect Waste	243	42.1%
Total	577	

Table 7: Contra Costa Food Bank's GHG Emissions Inventory for calendar year 2011. Source: Climate Action Plan for Food Bank of Contra Costa and Solano, 2012.

On deeper comparative analysis, I note that FBCENC's emissions per pound of food delivered (0.15lb CO_2) is much higher than that of Contra Costa (0.09lb CO_2), hence it is less energy efficient than its counterpart.

[29] Evans, Alexa. (2012). *Climate Action Plan for Food Bank of Contra Costa and Sol*ano. Retrieved from: http://www.cafoodbanks.org/docs/ClimateAction%20plan_8.20.12.pdf

	FBCENC (FY 2011-12)	Contra Costa (2011)
Total GHG Emissions ($mTCO_2e$)	1,734	577
Amount of food delivered (lbs)	24,465,526	13,800,000
lb CO2 emission per lb of food delivered	0.16	0.09

Table 8: Comparing the energy efficiency of 2 food bank's activities.

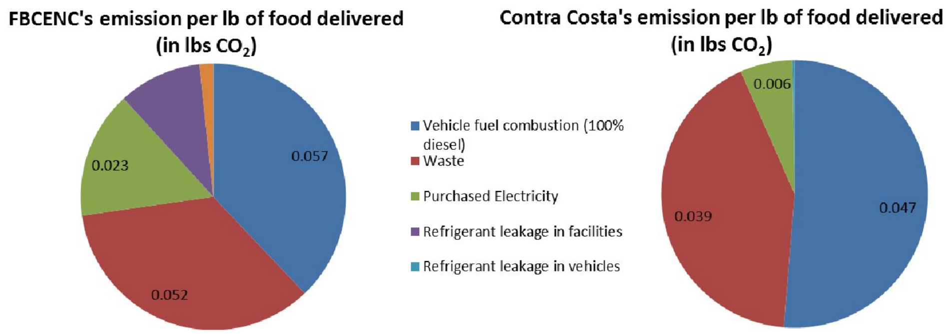

Figure 12: Comparative analysis on GHG emission sources at 2 food banks.

The higher energy use is attributed to higher emissions from electrical and waste per unit food distributed. Significantly, Contra Costa Food Bank has installed solar panels that provide >50% of the electrical needs of the food bank. Contra Costa Food Bank also has recycling programs for all forms of waste ranging from cardboard to shrink wrap, as well as food that cannot be distributed. These are normally sent to pig farmers or the Oakland Zoo. Waste recycling has reduced 592 $mTCO_2e$ of emissions, more than its current emissions[30].

These 2 efforts to reduce GHG emissions can be considered at FBCENC. In terms of solar energy, North Carolina has average photovoltaic solar resource, compared to other United States regions[31]. With roughly 250 days of sunshine, some analysts estimate the state has a potential to replace 22% of its current energy use with solar power.[32]North Carolina is the United States' largest pig farming state, and there is potential to find other uses of undistributed food.

If FBCENC donates the food waste in its waste stream, and manages to replace 22% of its energy requirements with solar power, it can reduce emissions per pound of food delivered to 0.12 lb. CO_2e, reduce total emissions by 300 $mTCO_2e$, increasing its GHG savings impact to 3 times of its own emissions.

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30 Evans, Alexa

31 National Renewable Energy Lab. (2012). [Photovoltaic Solar Resource of United States]. U.S. *Solar Resource Maps from NREL Dynamic Maps, GIS Data & Analysis Tools*. Retrieved from: http://www.nrel.gov/gis/images/eere_pv/national_photovoltaic_2012-01.jpg

32 Kaplan, S., Ouzts, E. (2009). *Growing Solar in North Carolina: Solar Power's Role in a Clean Energy Future*. NC: Environment North Carolina Research and Policy Center.

GHG implications of current growth trends

Knowing the two major sources of GHG emissions for FBCENC are its transportation mileage and waste helps us understand the GHG implications of its future growth. Two trends that FBCENC is experiencing are highly relevant to these 2 emission sources.

A recent study from North Carolina Agricultural and Technical State University analyzed the food donation trends for the past 5 years at FBCENC. It determined that food donations from retailers and wholesalers were increasing, while food donations from manufacturers were decreasing[33]. This trend is also mirrored generally by other food banks in Feeding America's network[34]. While an increase in donations, and hence a decrease in food waste to landfills, is a good outcome, retail store networks are highly dispersed and will likely result in more mileage travelled for pick up at manufacturer locations, which are generally fewer in numbers.

The second trend that the Feeding America network is experiencing is an increase in produce delivered. In the past 5 years, produce donations have increased 11%[35]. While this both reduces the amount of food wasted and improves the access to nutrition for those suffering from hunger, produce has a much shorter shelf life. Quick turnaround time, anchored by a large network of partners who can move food fast, is required to ensure there is no a corresponding increase in emissions from wasted food that had been recovered.

Energy implications if capacity is increased to meet demand

According to Feeding America's Hunger Report, nationwide it will require close to $21.8bn worth of food in order to eliminate hunger. This works out to be roughly 10.5bn pounds of food[36], about 3 times the amount of food Feeding America's network currently delivers. Supply wise, 10.5bn pounds of food is but 15% of the amount that is being wasted on a yearly basis in the United States. But in order to provide this food, the transportation, warehousing, delivery mechanisms of the food banking infrastructure would need to be expanded. Being concerned about achieving a positive environmental impact with food recovery, I wanted to understand what types of foods have a higher GHG emissions footprint or result in minimal food waste reduction.

I investigated the GHG emission footprint based on two characteristics – whether the food requires refrigeration and how the food is delivered to partners.

Food that requires refrigeration in this case encompasses all of produce, refrigerated and frozen foods. FBCENC does have separate cooling and freezing capacities in the warehouse, but in transportation, the refrigeration units are turned on to accommodate frozen goods. As such, on a high level, the analysis

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[33] Davis, L.B., Jiang, S. and Terry, J. (2013). *Empirical modeling of in-kind donations for a non-profit hunger relief organization*. Paper presented at Industry Studies Association Annual Conference. Kansas City, MO.
[34] Feeding America. Interview with staff from Supply Chain Group on 13 June 2013. Data provided after interview.
[35] Feeding America. Interview with staff from Supply Chain Group on 13 June 2013. Data provided after interview.
[36] Calculations are made based on Feeding America's average cost per meal of $2.67 and the average weight of 1.28lb. per meal. Average weight of meal is based on a study conducted in 1999 by Mathematica. See footnote 12 for reference.

does not differentiate between cooling and freezing requirements even if the energy intensity required is significantly different.

Food exits FBCENC in two main ways – it is either trucked out to branches and partners by FBCENC, or partners come to its warehouse to shop for food. From the March 2013 data, I note that in a regular month, 36% of the food that arrives in the warehouse is picked up from the warehouse by partners. Because each trip taken by FBCENC normally includes both pickups and deliveries, it is difficult to separately attribute a mileage to each. In the analysis, I assume 50% of the mileage is attributed to trucking in from donors to the food bank, and 50% of the mileage is attributed to trucking out to branches and partner agencies.

With these assumptions, I calculated the respective lb. CO2e footprint for 1 pound of food delivered.

Transportation Emission per lb of food delivered		
Basic average, every pound of food produces GHG from transport	0.072	lb CO2e
If you were a pound of food that needs refrigerated transport and trucked in/out	0.102	lb CO2e
If you were a pound of food that does not need refrigerated transport but trucked in/out	0.079	lb CO2e
If you were a pound of food that needs refrigerated transport and trucked in only	0.040	lb CO2e
If you were a pound of food that does not need refrigerated transport and trucked in only	0.031	lb CO2e
Warehousing Emission per lb of food delivered		
Basic average, every pound of food produces GHG from warehousing	0.045	lb CO2e
If you were a pound of food that needs refrigeration	0.064	lb CO2e
If you were a pound of food that does not need refrigeration	0.017	lb CO2e

Table 9: Breaking down the emission footprint per pound of food.

The analysis shows that trucking in and out of food bank results in a 2.6 times more GHG footprint than just trucking it one-way in, while requiring refrigeration at the warehouse yields a 3.8 times higher GHG footprint (*See Appendix 8 - Calculating the carbon footprint of each pound of food*).

This has implications for how food banks have to balance their energy requirements with the social need of providing more healthy fresh produce or meats, which are typically frozen, to those in need. It also begs the question if food banks should continue running the warehousing model, or provide themselves as a resource to manage the food network.

At FBCENC, 13% of the food it moves does not come through its warehouse at all[37]. Instead, its partner agencies pick up the food from donors within their vicinity directly. This has enabled FBCENC to reach more of its constituents without really increasing its footprint. Can this type of network management help to grow a food bank's capacity without incurring more transportation cost and emissions? Having knowledge of where to source donated food can be a major barrier for partner agencies. Many agencies are run by churches, or volunteers, who do not have the capacity to knock on doors of large retailers and ensure donations fit the food quality standards necessary. A food bank can be a trustworthy intermediary for these relationships.

[37] FBCENC. Interview with Supply and Inventory Department on 31 May 2013. Data provided for March 2013.

In terms of food waste reduction impact, I note that food received from TEFAP and purchasing have 0% food waste reduction impact. While TEFAP resources form one cornerstone of a food bank's ability to meet the needs of the hungry, food banks can only increase their impact on food waste reduction if they focus on building donor relationships with farmers, manufacturers and retailers. The increase in the amount of human resources, and transportation to enable this increase could be significant to the cost of operations of a food bank.

FINDING 2: GHG SAVINGS ARE SIGNIFICANT TO THE FOOD BANK IF MONETIZED

I've established that the food bank does significantly reduce GHG emission because of its role in food waste reduction. I also postulated that it would be beneficial to the food bank in both achieving its social mission and improving its environmental footprint, to improve its energy efficiency and to source more food from farmers, manufacturers and retailers. Both of these activities will require financial investment. If its GHG savings could be monetized, will it help the food bank achieve both these aims?

On a net emissions basis, FBCENC's Raleigh branch saved 4,360 $mTCO_2e$ for FY 2011-2012. At $7 per metric ton of carbon dioxide[38], this works out to $30,500 annually, based on their current level of activities. Appendix 9 shows details of the calculations that result in the following insights.

$30,500 can buy approximately 11,400 meals. With 1.8million hungry people, this money will reach an additional ~1% of the population for 1 meal a day. $30,500 is less than 0.5% of FBCENC's total (all six branches) annual budget and ~0.5% of the cash contributions that it receives on a yearly basis. From a financial standpoint, it seems rather insignificant.

However, $30,500 can pay for an additional staff, at the average annual compensation of $32,000, which could increase the food bank's ability to build more donor relationships. It is approximately 40% the cost of an additional refrigerated tractor-trailer. It also could have covered the major part of the lighting and control upgrades for energy efficiency FBCENC did in 2010. This one-time energy efficiency upgrade was estimated to save FBCENC $13,800 and 91 $mTCO_2e$ annually going forward. If FBCENC wanted to install solar paneling to reduce its energy costs, $30,500 could pay approximately 12% of the cost to replace one fifth of Raleigh branch's energy use. This could save FBCENC an additional $10,800 and 51 $mTCO_2e$ annually.

While the one-time financial outcome of monetization is small, especially when compared to the financial incentives for suppliers (waste haulage savings can be up to $25/ton of food), the resource implications could be significant in terms of expanding outreach and achieving better energy efficiency. If so, can food bank penetrate the carbon offset market? What would it take?

[38] Based on an annual report published by Ecosystems Marketplace on the Voluntary Carbon Offsets Market, the average price for carbon offsets sold by non-profit organizations in 2012 was $6.8/tCO_2e$.

FINDING 3: IT IS DIFFICULT FOR THE FOOD BANK TO ACCESS THE CARBON OFFSET MARKET

As a high level overview, the carbon offset market is one way individuals, governments and corporations seek to reduce their own carbon footprint. A purchaser of the offset is paying the seller (usually a project developer) of the offset to reduce carbon emissions elsewhere. The motivation for this reduction can be mandated by law (which drives the compliance market), or voluntary.

Compliance vs. voluntary markets

Compliance markets for carbon offsets are created by the existence of mandatory national, regional or international carbon reduction regimes. The carbon offset market is usually a supporting role in a cap-and-trade regime, where participants in the cap-and-trade regime are allowed to meet their caps through the carbon offset markets. The main example of this is UNFCCC's Clean Development Mechanism (CDM), which allowed countries that had ratified the Kyoto Protocol to fulfill part of their carbon emissions cap targets through financing approved carbon reduction projects (Certified Emissions Reductions or CERs) in developing countries.

Voluntary markets exists outside of the compliance market and allows all companies, governments, non-government organizations and individuals to offset their own carbon emissions. Voluntary emissions reduction can be motivated by a variety of reasons - pre-compliance intentions, corporate social responsibility image, a desire to make a personal impact, just to name a few. In this market, players can purchase CERs or offsets originating in the voluntary markets (Verified Emissions Reductions, or VERs).

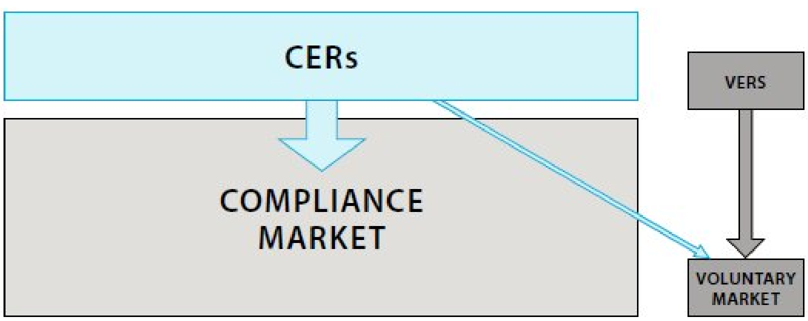

Figure 13: Overview of relationship between compliance vs voluntary markets. Source: Stockholm Environment Institute, Making Sense of the Voluntary Carbon Market: A Comparison of Carbon Offset Standards, March 2008.

The focus for this analysis is on voluntary markets, largely because the carbon reductions by food banks are made within the United States, and the United States is not an active participant in the Kyoto Protocol. Regional compliance regimes in the United States are isolated either by state (e.g. in California) or by industry (e.g. the Regional Greenhouse Gas Initiative for the power sector in the

Northeast). There are food banks in almost every state and regional rules and experience will not be relevant to all.

The voluntary market is small but growing fast. From 2006 to 2012, it had a compounded annual growth rate of 27% worldwide. In 2012, the voluntary market traded $523million worth of carbon offsets, representing 101 million tonnes of CO_2e (of which only 1 million tonnes of CO_2e were CERs) . This growth was despite a setback with the withdrawal of the Chicago Climate Exchange (CCX), which accounted for a large portion of the volume value traded in 2008/2009[39]. Out of this 101 million tonnes of CO_2e traded, 20.3million tonnes were sold by a North American project developer to a North American buyer. While still small, compared to the over 2 billion tonnes traded in the compliance markets, this market is deep enough to absorb new issuances. If Feeding America manages to get its carbon offsets recognized for all 10.5 billion pounds of additional food it needs to eliminate hunger in the United States, that will add roughly 1.2 million tonnes of CO_2e to the market[40].

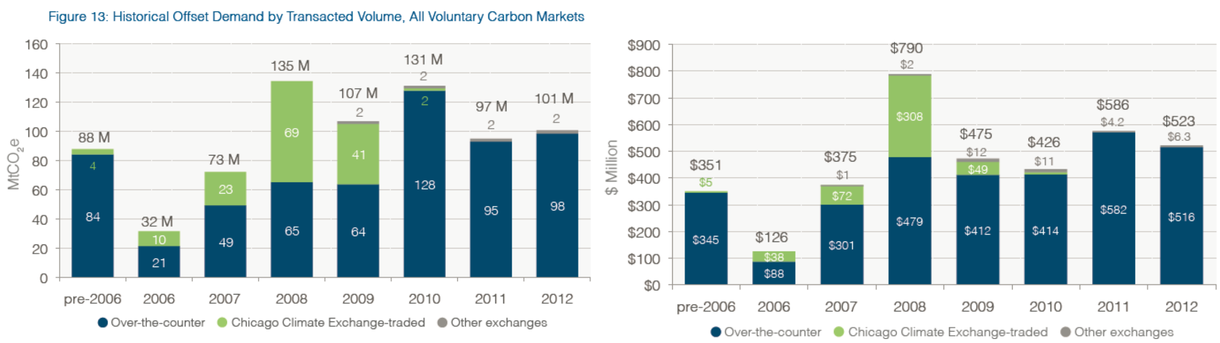

Figure 14: Comparing the traded volume (left) and value (right) growth of Voluntary Carbon Markets. Source: Forest Trends' Ecosystem Marketplace, State of the Voluntary Carbon Markets 2013.

There are many organizations that develop and manage the standards by which a CER or a VER is accounted for. For CERs, a CDM methodologies panel and an executive board administered by the UNFCCC manages this process. In the voluntary market space, organizations include the Gold Standard (GS)and Verified Carbon Standard (VCS).

While the compliance market has very stringent rules for developing and selling CERs, voluntary markets are more flexible. With less oversight and an intention to deepen the carbon market, many voluntary standard organizations allow for smaller, more innovative projects to participate in the voluntary market. For example, VCS has no lower limit on project size, and the average project size to date is

[39] Peters-Stanley, M., Yin, D. (2013). *Maneuvering the Mosaic: State of the Voluntary Carbon Markets 2013*. Forest Trends' Ecosystem Marketplace and Bloomberg New Energy Finance.
[40] Based on the above analysis, taking into account that approximately 58% of the food distributed through food banks is considered "recovered from landfills", and that every lb. of food move saves 0.39lbs. of CO_2e.

160,000 tCO_2e[41]. In comparison, the current average project size for projects under the CDM regime is approximately 580,000 tCO_2e[42].

But because of the relaxation of rules, the price of carbon offsets in the voluntary market varies over a large range. The average price in 2012 was \$5.9/tCO_2e for instance, but range of price traded was between \$0.1/tCO_2e - \$100/tCO_2e. The price differences reflect different level of quality, as perceived by meeting the criteria for offsets, as well as how "charismatic" an offset project is. For example, while the global average price was \$5.9/tCO_2e, offsets sold by non-profits had a higher average of \$6.8/tCO_2e[43].

Requirements of a carbon offset

While standard organizations in the voluntary market are more flexible, and purchasers in the voluntary market require different levels of assurances regarding the quality of an offset, at the very least, an offset must be[44]:

- Real: GHG reductions must represent actual reductions from a baseline scenario.
- Additional: Reductions must be surplus to regulation and beyond what would have happened in the absence of the project or in a business-as-usual scenario.
- Permanent: Reductions must be permanent (non-reversible, as in a case of terrestrial sequestration) or have guarantees to ensure that any losses are recaptured in the future.
- Verifiable: Reductions accrue from projects whose performance can be readily and accurately quantified, monitored and confirmed.

Each requirement in this list poses obstacles to the feasibility of monetizing of a food bank's contribution to carbon emissions reduction. I will highlight these in turn, as I analyze the accessibility of the carbon offsets market to non-profit and non-revenue generating organizations like food banks.

Criteria 1: Real – Developing new standards for food waste recovery is expensive

In order to know that any carbon emissions reduction is a true reduction, there must be methodologies to assess a projects impact on carbon emissions, compared to a baseline. These standards and protocols cover how a carbon emissions reduction project needs to be designed and how the emissions are calculated in a baseline scenario compared to the project scenario. Protocols are mostly developed by third-party standard organizations, like VCS, although a very small percentage of standards are internally developed. About 3% of the voluntary offsets traded in 2011 were internally developed, which is roughly

[41] The VCS Project Database. Retrieved on 3 December 2013, from: http://www.vcsprojectdatabase.org/
[42] CDM Insights. *Project Activities*. Retrieved on 3 December 2013, from: http://cdm.unfccc.int/Statistics/Public/CDMinsights/index.html
[43] Peters-Stanley and Yin.
[44] Moretti, C., Burman, P. (2009). *Responsible purchasing guide: carbon offsets*. Oakland, CA: Responsible Purchasing Network.

about 2.8 million mT CO_2e[45]. However, internal standards rely a lot on mutual trust and cooperation between the purchaser and the seller that the standards developed have enough integrity to result in real reduction. It might be difficult for the seller to have credits registered and officially count as a reduction, impacting its attractiveness to purchasers.

There are no available standards for food waste recovery as a means of carbon emissions reduction. Standards exist for landfill gas reduction whether it is simple flaring or energy production[46]. Composting standards also exist and new ones are under development[47]. While source reduction is the preferred food waste reduction method, its environmental contributions are not yet recognized in the carbon offset market.

New standards do get created, and while non-profits do play a large role as suppliers of voluntary offsets (about 14% of 2012 voluntary offsets were provided by non-profits[48]), it is not as common for a non-revenue generating entity to sponsor the creation of a new standard because the process can be long, expensive and convulated. One new protocol for a not-for-profit purpose is Maine Housing Authority's weatherization program aimed at low income housing. This protocol was funded by a consortium of the Pennsylvania Housing Finance Agency (PHFA), New Jersey Housing and Mortgage Finance Agency (NJ HMFA), the Ford Foundation and ARRA funds through the US Department of Energy (DOE)[49]. To enable this protocol development, the Maine Housing Authority had to conduct a 4 year long quantification project (from 2008-2012) to test the tools required to verify carbon offsets from home energy efficiency upgrades[50]. Another lesson that is pertinent to the new standard process is the complexity of the rules and their practicability. One story of the CDM protocol development for the use of compact fluorescent lamps (CFLs), tells of how the protocol development went through multiple iterations and changes that later on it was no usable for any CFL distribution program in the field at all[51].

The biggest issue for individual food banks would be the lack of capacity, financial as well as time, to conduct the required pilots and tests to develop a protocol.

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[45] Peters-Stanley, M., Hamilton, K. (2012). *Developing Dimensions: State of the Voluntary Carbon Markets 2012*. Forest Trends' Ecosystem Marketplace and Bloomberg New Energy Finance.

[46] For example, CDM's methodology "*ACM0001: Flaring or use of landfill gas --- Version 15.0.0*" can be applied for projects that flare landfill gas, produce electricity with landfill gas in places where landfill gas recovery is not mandated by law. In the United States, the Climate Action Reserve's "*US Landfill Project Protocol*" provides guidance to quantify, report, and verify GHG emission reductions associated with installing a landfill gas collection and destruction system at landfill operations.

[47] For example, CDM's methodology "*AMS-III.F.: Avoidance of methane emissions through composting*" can be applied to projects that replace solid waste disposal sites, animal waste management system, or wastewater treatment system with controlled aerobic treatment of composting. In the US, the Climate Action Reserve recently released "*Organic Waste Composting Project Protocol*" for public comment.

[48] Peters-Stanley and Yin.

[49] Climate Focus. No date. *Projects: Weatherizng Maine's Homes*. Retrieved from: http://www.climatefocus.com/pages/weatherizing_maines_homes

[50] MaineHousing. *Carbon Quantification Project*. Retrieved 3 December 2013 from: http://www.mainehousing.org/about/carbon

[51] Michaelowa, A., Hayashi, D., Marr, M. (2009). Challenges for energy efficiency improvement under the CDM—the case of energy-efficient lighting. *Energy Efficiency, 2*, p353–367. doi: 10.1007/s12053-009-9052-z.

Criteria 2: Additional – Beyond business-as-usual reduces GHG benefits recognized

The need to meet additionality is crucial. Carbon offsets are not meant to fund carbon emission reductions that would have taken place anyway. There are two main ways of viewing additionality – regulatory surplus and beyond business-as-usual.

Any carbon emissions that are required by state or any other regulation would have had to occur anyway. In this case, there is no outright regulation on carbon emissions in the food banking industry as of now.

Beyond business-as-usual requirement will be harder for a food bank to establish. Given that most food banks are social organizations that had been set up many decades before and the obvious need in the society supports their continued existence, how can food banks meet this requirement?

A recent protocol under development by the Climate Action Reserve for composting gives an idea how beyond business-as-usual can be defined. In order for any composting project to meet additionality requirements, they will need to document the amount of food and soiled paper waste that the grocery store had sent to a landfill in the 36 months prior[52].

In effect, this is creating a baseline – how much do you normally send to landfill – making it possible to compare post-project how much actual waste was redirected from landfills to composting. A similar approach could be taken for food bank expansion. It can be established how much food banks were able to divert from landfills for the last three years. Using that as a baseline, it can be shown how the projects (whether as an investment in new trucks, or new refrigeration capacity) have increased the food waste reduction.

The biggest concern meeting this criteria is that the amount of reduction and the corresponding funds raised would be much smaller than if the full contribution of food banks were recognized.

Criteria 3: Permanent – Leakages need to be quantified

Carbon emission reductions that are not permanent, either because of temporal leakages or reversals need to be managed. The most widely cited case on reversals is for projects that rely on terrestrial sequestration. Overtime, the carbon is re-released into the atmosphere. In this case, a relevant leakage could be emissions from the human waste stream which is an eventuality of eaten food products. Factors that affect the amount of emissions from this leakage include whether the wastewater facilities are equipped to capture the biogas and conduct flaring, or use it for energy production.

Another aspect of permanence is the idea that offsets, if continually traded do not result in an actual reduction in overall carbon emissions. Since a new emitter can effectively offset its emission by buying

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[52] Climate Action Reserve. (2013). *Organic Waste Composting Project Protocol Avoiding Methane Emissions by Aerobically Composting Food and Food Soiled Paper Waste (Version 1.1 for Public Comment)*.

offsets in the secondary market, carbon emissions are only reduced on a global scale when an offset is retired. The management of tradable offsets versus retired offsets rely on registries that assign each carbon offset a unique identifier. The voluntary market has a number of registries and while they are not currently linked, a registered offset from any of the well reputed registries definitely commands a higher value than offsets that go unregistered. Registries typically charge an annual fee and per-credit registration fee.

The concerns in meeting the permanence criteria are the additional cost of registering offsets as well as developing the methodologies to quantify leakage and ensuring emission reductions are still significant after taking into account the leakage.

Criteria 4: Verifiable – Cost of implementation too high for individual food banks

Quantification, validation (pre completion) and repeated verification of the amount of reductions are essential to ensuring reductions truly occur. Different standards have different verification processes. VCS require a third party verification, and has a list of certified verifiers. They allows for validation to be conducted the same time as the first-time verification post project, hence reducing the one-time cost. One private buyer of credits notes that verification is usually required at least every two years and each third-party verification can cost upwards of $10,000[53].

For food banks, even if its full environmental impact can be monetized, this verification cost, at $5000 per year, can be a large proportion of the financial revenue from selling offsets. FBCENC, distributes 45million pounds of food a year and is ranked in the top 15 in Feeding America's network for amount of food moved. And yet, this verification cost would represent >10% of its possible revenue.

The key concern here is how to structure a carbon offset production project that uses this fixed overhead cost more efficiently. A larger aggregated emissions reduction potential, for example, from the umbrella organization Feeding America would make this cost negligible.

[53] Duke Carbon Offsets Initiative. Interview with staff member on 18 February 2013.

SUGGESTIONS FOR HARNESSING THE ENVIRONMENTAL BENEFITS

A proposition for consideration

Taking into consideration the need for carbon offset buyers to establish quality, a lot more research will be needed to replicate similar studies across different food banks and to investigate the impact of system leakages, amongst other challenges. I suggest possible funding and project structures that could mitigate two of the hurdles highlighted in above analysis of carbon offset market accessibility.

Funding consortium interested in food waste reductions' social and economic impacts

Emulating the success of the Maine Housing Authority's funding coalition to enable weatherization installations in low income housing, I believe it is possible to put together a consortium of funders that are both interested in increasing the capacity of food banks as well as reducing the amount of food waste in the current food system to investigate the feasibility and if possible, eventually fund the development of a protocol. Some suggestions include

(i) foundations who are current funders of Feeding America, like the AARP Foundation;
(ii) local governments which have waste reduction as part of their climate action plans;
(iii) federal government departments, like the USDA, which have a vested interest in improving the economic efficiency of the food system;
(iv) large manufacturers which are currently part of the Food Waste Reduction Alliance (FWRA),like General Mills.

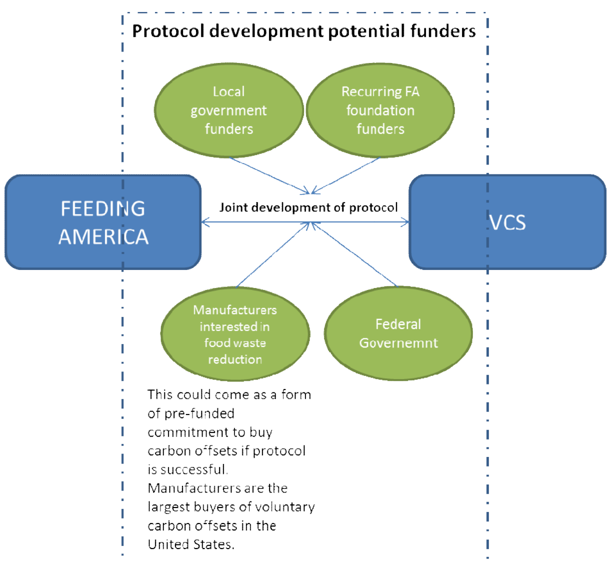

Figure 15: Potential funders of a protocol development for food banks' food waste reduction

For the federal government, food waste represents $145bn of production losses[54] and 300 million barrels of oil wasted[55] on an annual basis. Improving the ability of food banks to recover edible foods improves efficiency of the production system.

Local governments with Climate Action Plans have multiple interests that could motivate them to participate in such an endeavor. One is purely from a waste reduction perspective. For example, the City of Raleigh calculates its waste landfill emissions to be 33,000 $mTCO_2e$ in 2007[56]. As I have shown, the FBCENC's Raleigh branch's hunger relief operations decreases landfill emission by 4,360 $mTCO_2e$ a year at its current size. Scaling up its operations by 50% can help contribute to a 7% reduction in landfill emissions for the city.

Second, many cities' Climate Action Plans have establish goals of improving the health of communities through local and fresh food movements.[57] These goals can be extended to improving the access to fresh produce for food insecure population. Testament to this is the City of Oakland's Food Policy Council's 2010 Food Action Plan. The council was created to "analyze the Oakland food system from production through consumption and waste management, and recommend changes to make the system more equitable and sustainable". Out of its 10 recommendations, 3 of them directly address access to better food for underserved communities[58].

Thirdly, some Climate Action Plans specifically want to reduce the use of greenhouse gas intensive Hydrofluorocarbons (HFCs). Refrigeration upgrades for commercial facilities play a large role in the reduction of HFCs use. Food banks can benefit from refrigeration capacity upgrades through monies raised through the carbon offset markets.

Efforts to target large manufacturers and other corporate funders have been one of Feeding America's key funding strategies. For example, FBCENC benefits from large donations from food companies like Food Lion, as well as other corporations like Cisco, who provide both financial as well as volunteer support. Corporate funders, especially those connected to the food industry can participate not only through funding the protocol, but also by pre-funding credits to be sold once the food banks design projects that meet the developed standards.

Minimize overhead costs by developing projects at the umbrella organization level

The costs of protocol development, project design and validation, offset registration, and annual (or bi-annual) verification could be prohibitive for smaller organizations. Whether the project is to increase

[54] Gunders, Dana.
[55] Hall, K., Guo, J., Dore, M., Chow, C. (2009). The Progressive Increase of Food Waste in America and Its Environmental Impact. *PLoS ONE, 4,* Issue 11: e7940. doi:10.1371/journal.pone.0007940
[56] ICF International. (2010). *City of Raleigh Greenhouse Gas Inventory: Municipal Operations*. Durham, NC: ICF International.
[57] Climate action plans for the City of Portland (Progress Report for 2010), City of Cincinnati (2008, Version 4.0) and City of Chattanooga (2009) were reviewed and had plans to meet established goals for improving the health of communities through local and fresh food movements.
[58] Oakland Food Policy Council. (2011). *Transforming the Oakland Food System: A Plan for Action*. Oakland, CA: Oakland Food Policy Council.

real asset capacity (e.g. refrigeration or trucking facilities), reduce energy costs (e.g. by installing solar capacity) or establish better distribution network for fresh produce, projects should be developed by umbrella organizations like Feeding America to distribute the overhead costs across a larger potential number of offsets that can be produced.

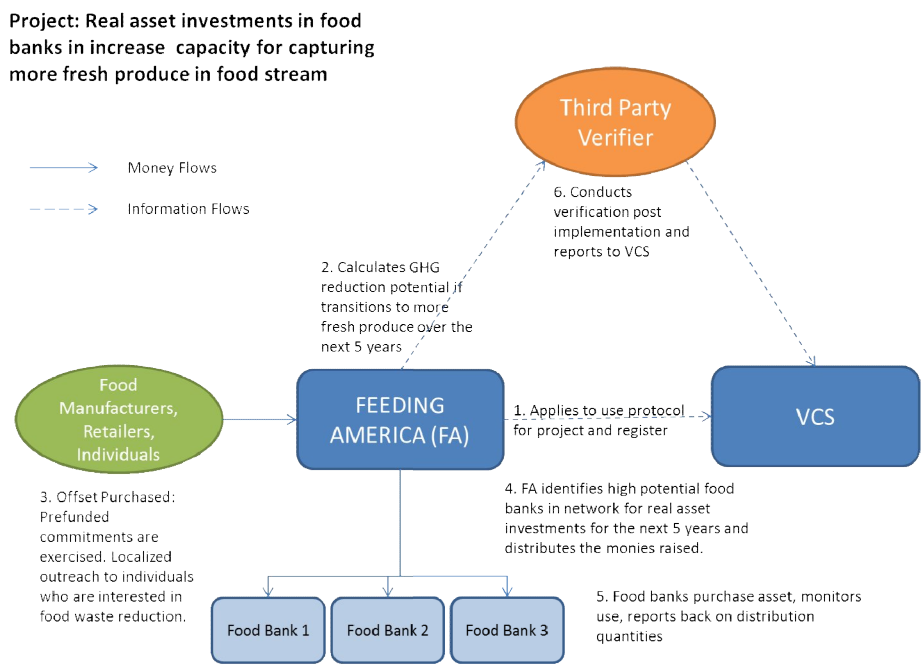

Figure 16: Developing projects at the umbrella organization level to reduce overhead costs.

Such a proposal, would involve several steps:

1. Feeding America would first apply to use the project protocol it has developed with a carbon standard organization, like VCS.
2. It will then draft the project documentation that calculates the GHG reduction potential because of an increase in capacity throughout its network from project implementation.
3. At project implementation, food related corporations or individuals who are interested in food waste reduction would purchase offsets, some of which were pre-funded commitments in the protocol development phase.
4. Feeding America would use funds raised to distribute to food banks within its network that can achieve the capacity increases with new real asset investments.
5. The food banks' progress would be monitored through the existing reporting system which Feeding America uses to aggregate the amount of food delivered.
6. A third party verifier would conduct the first verification post implementation and report these verifications through VCS, so offset buyers can be assured of progress and the existence of the GHG reductions.

This is a stylized example of how monies raised at the umbrella organization level can directly impact the capacity of food banks at a local level. Certainly, many hurdles will need to be resolved at implementation.

If not offsets, how else?

There are many challenges in monetizing a food bank's GHG reduction through the carbon offsets market. Further analysis can be conducted to better understand other ways a food bank can capitalize on its contribution to greenhouse gas reductions.

At least on the corporate front, corporations who aim to be leaders in climate change and adaptation are motivated to fund energy efficiency upgrades and help improve a food bank's operational efficiency. For example, Walmart funded $2million worth of energy efficiency audits and upgrades at food banks in 2010[59]. Toyota recently concluded a high-profile collaboration with Food Bank For New York City that enabled it to increase "the amount of meals transported in the delivery truck by almost 50 percent, from 864 boxes to 1260"[60], amongst other things. Being able to highlight how its efforts indirectly reduces landfill emissions would be an additional marketing and branding benefit for a corporation's CSR image.

Individuals who are green conscious are another target audience for the food bank to highlight its environmental contributions. The number of individuals who have bought offsets have doubled between 2010 and 2011[61]. New crowdfunding sites focused on clean energy, like Solar Mosaic, have also gained a lot of traction in the last 2 years. Both of these examples point to increasing interest by individuals to financially contribute to projects that reduce greenhouse gas emissions. Further donor analysis can be conducted to understand :

(i) how current donors will change their donation patterns if they knew the environmental benefit their dollars were generating,

(ii) whether new individual donor pools can be reached if the environmental benefits are marketed.

All in all, while this analysis show a food bank can now establish the environmental benefit it provides, further analysis is required to build collaborations and identify new donor pools.

[59] Environmental Leader. (2011, 19 January). Walmart Gives $2m For Food Bank Energy Efficiency. *Environmental Leader*. Retrieved from: http://www.environmentalleader.com/2011/01/19/walmart-gives-2m-for-food-bank-energy-efficiency/

[60] Toyota In Action. Meals Per Hour: A car company. A food bank. A mission. Retrieved 3 December 2013 from: http://www.toyotainaction.com/story/meals-per-hour#latest-news

[61] Peters-Stanley, M., Hamilton, K.

CONCLUSION

The amount of food waste generated annually and its resulting greenhouse gas emissions is an environmental as well as economic burden. Diverting food wasted to other productive economic use increases the economic efficiency of the $145billion spent on food production. Reducing all emissions from food waste is equivalent to nearly half the 2012 estimated reduction of 540 unbuilt landfill gas recovery projects in the United States. If 15% of the food waste could be recovered and re-delivered, it could mean cutting food insecurity in the United States by half.

Suppliers in the food recovery system have the economic incentive to donate wholesome food. Aside from legal liabilities, they find it difficult to donate more because of the lack of asset capacity at the buyers. Food banks and food pantries, the buyers in this system, are run as non-profits and have financial capacity constraint in asset upgrades.

This analysis has shown that a typical food bank that focuses on warehousing and delivery of food can save up to 2.5 times of its own operational emissions. This savings is significant. In the context of Food Bank of Central and Eastern North Carolina, their savings of 4,360 $mTCO_2e$ is more than 10% of the current landfill emissions of the City of Raleigh. Being able to increase their capacity by 50% would reduce landfill emissions by 7%. For FBCENC, if this greenhouse gas reduction could be monetized through the carbon offset markets, it would represent an ability to deliver 11,400 additional meals, increase staff headcount, or subsidize investments new assets or energy efficiency upgrades.

Many hurdles exist to achieve monetization of greenhouse gas reduction in the carbon offset markets. Developing a protocol of food waste recovery, and subsequent monitoring of projects can be costly. This is especially so for a non-profit, non-revenue generating entity like a food bank. This study proposes structures that can lower some of the hurdles, but would require active participation by key funders and an umbrella organization for food banks, like Feeding America.

I believe that there exist high potential for food banks to tap funding from corporations and individuals with a new message of its environmental benefit. Its dual impact outcome can be a strong selling point and more market analysis should be done to identify new fundraising targets.

LIST OF APPENDICES

Appendix 1 – Calculating food waste recovery's impact on landfill emissions

EPA's WARM model version 12 (Feb 2012) was used to estimate the emissions from all the food waste generated in the United States in a year.

The WARM model used is available as an online form here:
http://epa.gov/epawaste/conserve/tools/warm/Warm_Form.html

Please see note in Appendix 6D for the life cycle emissions that the WARM model captures.

Two key assumptions users have to make in the WARM's calculation of GHG emissions is whether a landfill has landfill gas recovery in place and the distance that will be travelled by the waste to the landfill. For this nationwide estimate, the WARM model is set to calculate at default options national averages.

For ease of comparison to landfill gas recovery's energy recovery potential measured in MMTCE, the WARM model is set to calculate emissions in MTCE.

For this GHG Inventory, the online WARM form was used with the following parameters:

Food scraps landfilled: 33,000,000 tons (66,000,000,000 lbs)

GHG Emissions calculated in MTCE = 6,195,638 MTCE

8/29/13 GHG Emissions Analysis — Summary Report

GHG Emissions Analysis — Summary Report

(Version 12, 2/12)

Analysis of GHG Emissions from Waste Management

GHG Emissions from Baseline Waste Management Scenario (MTCE):	6,195,638
GHG Emissions from Alternative Waste Management Scenario (MTCE):	6,195,638
Total Change in GHG Emissions (MTCE):	**0**

	Baseline Scenario					Alternative Scenario						
Material	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Total MTCE	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Total MTCE	Change (Alt - Base) MTCE
Food Scraps	N/A	33,000,000	0	0	6,195,638	0	N/A	33,000,000	0	0	6,195,638	**0**

Note: A negative value indicates an emission reduction; a positive value indicates an emission increase.
a) For an explanation of the methodology used to develop emission factors, see EPA report: Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste (EPA530-R-98-013) — available on the Internet at http://www.epa.gov/climatechange/wycd/waste/reports.html Please note that some of the emission factors used to generate these results do not match those presented in the report due to recent additions and/or revisions.
b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

Figure 1 – Report generated by WARM model for Total Food Waste Emissions

Appendix 2 - Example of a food bank's budget

In both 2011 and 2012, the food donations made up 90% of the revenues for the food bank and program service expenses made up 97% of expenses.

	2012	2011
Changes in Unrestricted Net Assets:		
Support and revenues:		
Food donated	$76,466,705	$71,540,113
Shared maintenance—agencies	1,094,966	960,741
Food purchase programs	249,091	243,121
Contributions	4,900,999	4,473,266
United Way	196,002	272,001
Governmental awards	1,501,434	1,166,357
Goods, services, and facilities contributed	65,513	206,335
Food drives and other fundraising events	349,216	378,485
Interest	10,797	20,101
Other	37,252	2,800
Loss on disposal of fixed assets	(2,224)	(6,860)
Loss on sale of investments		(820)
Total unrestricted support and revenues before restrictions released	84,869,751	79,255,640
Net assets released from restrictions	1,687,421	1,468,547
Total unrestricted support and revenues after restrictions released	86,557,172	80,724,187
Expenses:		
Program services	84,393,689	78,342,159
Management and general	926,401	872,978
Fundraising	1,914,939	1,807,774
Total expenses	87,235,029	81,022,911
Decrease in unrestricted net assets	$(677,857)	$(298,724)

Source: FBCENC 2012 Annual Report.

Appendix 3 – Feeding America's Map the Meal Gap project

In order to better understand the face of hunger at the local community level, Feeding America undertook the Map the Meal Gap project. It intends to use more indicators than the federal poverty threshold to better characterize the extend of populations who are food insecure. National food insecurity data reveal that the federal poverty is an inaccurate measure of food insecurity – "56% of the those struggling with hunger actually have incomes above the federal poverty level and 58% of poor households are food secure"[62].

The USDA defines food insecurity as both reduced quality, variety and desirability of diet as well as reduced food intake or disrupted eating patterns.[63]

Feeding America's Map the Meal Gap (MMG) project uses a statistical model to analyze the relationship between food insecurity and indicators like poverty, unemployment, median income, etc at the state level. Details of the statistical model can be reviewed in the Technical Brief (2010) available at Feeding America's Map the Meal Gap website: http://feedingamerica.org/hunger-in-america/hunger-studies/map-the-meal-gap/overall-food-insecurity-estimates.aspx#

Based on the MMG statistical model, the US National average food insecurity rate is 14.7%. The following states of statistically significant higher household food insecurity rates than the US national average:

State	Statistical Food Insecurity Rate
Mississippi	20.9%
Arkansas	19.7%
Texas	18.4%
Alabama	17.9%
North Carolina	17.0%
Georgia	16.9%
Missouri	16.7%
Nevada	16.6%
Ohio	16.1%
California	15.6%

[62] Feeding America. (2013). *Map the Meal Gap: Overall Executive Summary*. Retrieved 3 December 2013 from: https://feedingamerica.org/hunger-in-america/hunger-studies/map-the-meal-gap/overall-food-insecurity-estimates.aspx

[63] United States Department of Agriculture, Economic Research Service. *Definitions of Food Security*. Retrieved from: http://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/definitions-of-food-security.aspx#.Uo2KVcSa6Hg

Appendix 4 – GHG Inventory: Impact of activities outside of FBCENC's operational boundaries

The GHG Inventory compiled for FBCENC excluded the activities from the production, retail, consumption and waste phases because these are outside the operational control of the food bank. However, it is likely that inclusion of the greenhouse gas impacts of these phases could significantly impact the overall emissions profile.

Production Phase – Embedded energy of food production

The embedded energy in food's life cycle prior to consumption include energy from agriculture production, harvest, handling, storage, processing and distribution. According to a FAO report, the total carbon footprint of the food wastage that occurs in North America is 900kg CO_2 eq per capita[64]. Expressed in terms of the estimated tonnage of food waste, each pound of food wastage has an embedded carbon footprint of roughly 9.3 lb CO_2 eq. About 60% of this carbon footprint is prior to the consumption phase, i.e wasted food that is potentially recoverable by the food banking system has an embedded carbon footprint equivalent to 6 times its own weight.

Retail Phase – Distribution to retail channels (partner agencies)

Food leaves the food bank in two ways – it is either trucked out by FBCENC trucks (emissions covered in the Scope 1 vehicle emission) or it is picked up by the partners at its warehouses. FBCENC has 800 partner agencies that it supplies[65]. FBCENC routinely delivers to some of these partners[66] although a large majority of these partner agencies come to FBCENC's 6 warehouses to "shop" for their food needs. Given that FBCENC covers 34 counties with only 6 of these warehouses, the travelling distances of these partner agencies can be quite significant and has potential to increase the amount of GHG emissions.

Consumption Phase – Food preparation and packaging

The preparation and cooking processes of the partner agencies can also be an energy intensive activity. According to National Restaurant Association, the restaurant business utilizes 5 times the energy per square foot of any other type of commercial space and on average 35% of this energy is attributed to the cooking process[67]. Depending on how many partner agencies run kitchens, and also the cooking processes (cooking in large batches is expected decrease the energy intensiveness per distributed pound

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[64] Food and Agriculture Organization of the United Nations. (2013). *Food Wastage Footprint: Impacts on Natural Resources.* Geneva:FAO.

[65] FBCENC. *Homepage*. Retrieved on 3 December 2013 from: http://www.foodbankcenc.org/site/PageServer?pagename=FBCENCHome

[66] Food inventory from Raleigh branch for the month of March 2013 shows that 36% of the total food distributed by the food bank was picked up by partners at the warehouse.

[67] United States Environmental Protection Agency. (2012). *ENERGY STAR® Guide for Restaurants: Putting Energy into Profit* (EPA 430-R-09-030). Washington, DC: U.S. Government Printing Office.

of food), this could be another contributor to increasing the ultimate GHG emissions of providing food to the hungry through the current food banking system.

Waste Phase – Does it all get eaten in the end?

Lastly, the wasted food through non-consumption is estimated to be low. Anecdotally, it is possible that many recipients of food discard whatever they dislike to eat. However, this possibility is mitigated by the fact that food banks and food pantries are now less “dictatorial” in the food they distribute. In the past, a fixed package would be delivered but now food pantries are free to “shop” for food they know they require or their constituents would go for/need. Secondly, based on conversations with FBCENC, the food they provide only meets 8-10% of the food needs of food insecure population in the region of service[68]. Hence, it is reasonable to assume that little of the food they provide is wasted.

[68] FBCENC. Interview with staff of Operations Department.

Appendix 5 – Data sources and calculation assumptions

The following tables list the data items used in the calculations for the FBCENC case study and their corresponding data source.

Table 1 lists data used specifically for the GHG Inventory only. Table 2 lists data used in other calculations. Some of the data is used to attribute a specific line item from the GHG Inventory report between different types of food. For example, the % of food delivered by the food bank that does not come through food bank warehouses is calculated to ensure the amount of GHG emissions from transportation is attributed only to food that comes through the food bank.

Table 1 –Data Used in GHG Inventory

Emission Scope	Data Item	Time Period	Data Use Description	Source	Emission factor used[69]
Scope 1: Direct Emissions from Stationary Combustion	Natural gas consumption	Annual FY 2011-2012	Calculate GHG emission from heating capacity	FBCENC, Operations Department	Natural Gas Emission Factor: 0.054 kg CO_2/scf
Scope 2: Indirect Emissions from Electrical Use	Electrical consumption	Annual FY 2011-2012	Calculate GHG emission from electrical use	FBCENC, Operations Department	eGRID power pool-specific factor for zipcode 27609[70]: 1035.869 lb CO_2/MWh

[69] Unless stated, emissions factors are based on calculation methodologies provided in "General Reporting Protocol for the Voluntary Reporting Program" (GRP) by The Climate Registry (May 2008).
[70] EPA eGrid Power Profiler Zip Code Tool v4.1 (Mar 2013) available at: http://www.epa.gov/cleanenergy/documents/egridzips/Power_Profiler_Zipcode_Tool_v4-1.xlsx

Emission Scope	Data Item	Time Period	Data Use Description	Source	Emission factor used[69]
					0.0215 lb CH_4/MWh 0.0174 lb N_2O /MWh
Scope 1: Direct Emissions from Fugitive Emissions	Refrigerant recharge	Annual FY 2011-2012	Calculate GHG emission from refrigerant leakage	FBCENC, Operations Department	Global Warming Potential (GWP): R22 – 1810 per metric ton refrigerant[71] R404A – 3260 per metric ton refrigerant
Scope 3: Other indirect Emissions	Weight of food waste leaving food bank	Annual FY 2011-2012	Calculate GHG emission from wasted food	FBCENC, Operations Department	WARM model assumptions used
Scope 1: Direct Emissions from Mobile Combustion	Fuel consumption and mileage travelled by truck (inclusive of fuel for refrigeration)	Annual FY 2011-2012	Calculate GHG emission from miles travelled	FBCENC, Operations Department	Diesel Emission Factor: 8.81 kg CO_2/gal 0.0048 g CH_4 /mil 0.0051 g N_2O /mil

Table 2 – Other data used

Data Type	Data Item	Time Period	Data Use Description	Source
Food Resources	Total amount of food delivered by food bank	Annual FY 2011-2012	Calculate amount of GHG emissions that is saved from food waste reduced	FBCENC, Operations Department
Food Resources	Breakdown of food delivered by the food bank that is:	Annual FY 2011-2012	Calculate amount of GHG emissions that is saved	FBCENC, Operations Department

[71] The R-22 refrigerant's GWP was not available in the GRP document. GWP for R-22 obtained from EPA's Factsheet: *Transitioning to Low-GWP Alternatives in Commercial Refrigeration* (Publication No: EPA-430-F-10-043) issued in October 2010.

Data Type	Data Item	Time Period	Data Use Description	Source
	- Federal commodities - Manufactured goods - Retail - Produce - Purchased		from food waste reduced	
Food Resources	Breakdown of food delivery method[72]: - Partner on-site shopping - Delivery to partners by truck or similar	For month of March 2013	Attribute GHG emissions for transportation	FBCENC, Product and Inventory Control
Food Resources	% of food delivered that does not come through food bank warehouses[73]	For month of March 2013	Attribute GHG emissions for transportation	FBCENC, Product and Inventory Control
Food Resources	Weight of food collected in Raleigh by food storage method - Dry - Produce - Refrigerated - Frozen	Annual FY 2011-2012	Attribute GHG emissions for refrigeration only to non-dry foods	FBCENC, Operations Department
Electrical Consumption	Square footage of office space vs warehouse space	Annual FY 2011-2012	Attribute electrical usage to food	FBCENC, Operations Department
Warehousing	Clear Energy's Energy Audit	2010	Establish cost of energy efficiency upgrades	FBCENC's Operations Department
Transportation	Odometer readings	For first full 2	Estimate travel distance to	FBCENC, Transportation

[72] For this attribution we are interested in how much food is not trucked at all to and from FBCENC, how much food is trucked once to FBCENC and later picked up by partners from its warehouse, and lastly how much food is trucked into and out of FBCENC. The amount of food leaving the food bank and its Shipping Agent Codes are used to make the distinction.

[73] The Raleigh Food Bank covers 34 counties in North Carolina. Food donors for example Food Lion and Walmart have extensive operations within these 34 counties. Where it makes sense, Raleigh Food Bank encourages direct food delivery between a Food Lion and their partners within closer proximity.

Data Type	Data Item	Time Period	Data Use Description	Source
		weeks of March 2013	landfills in “no foodbank” scenario	Department
Transportation	Addresses of donors to the food bank	For first full 2 weeks of March 2013	Estimate travel distance to landfills in “no foodbank” scenario	FBCENC, Transportation Department
Transportation	Landfill locations in North Carolina		Estimate travel distance to landfills in “no foodbank” scenario (see Appendix 7)	North Carolina Department of Environment and Natural Resources
Transportation	Road Network Dataset in North Carolina		Estimate travel distance to landfills in “no foodbank” scenario (see Appendix 7)	North Carolina Department of Transportation
Organizational Level	Revenue	FY 2011 - 2012	Establish financial significance of carbon offset sales	FBCENC’s Form 990 obtained from Guidestar

Appendix 6 – GHG Inventory report for FBCENC Raleigh branch

Purpose of GHG Emissions Inventory

This greenhouse gas emissions inventory is a collaboration between the Food Bank of Central and Eastern North Carolina (FBCENC) and Duke University's Nicholas School Master of Environment Management student, Xinying Tok. The goal is to better understand the food bank's operational greenhouse gas emissions in order to:

1) Gain insights on opportunities to improve operational efficiency and reduce emissions;
2) Compare the operational emissions with the emissions saved through the food waste diversion of the food bank's work;
3) Inform various food bank stakeholders of the environmental impacts of the food bank's operation;

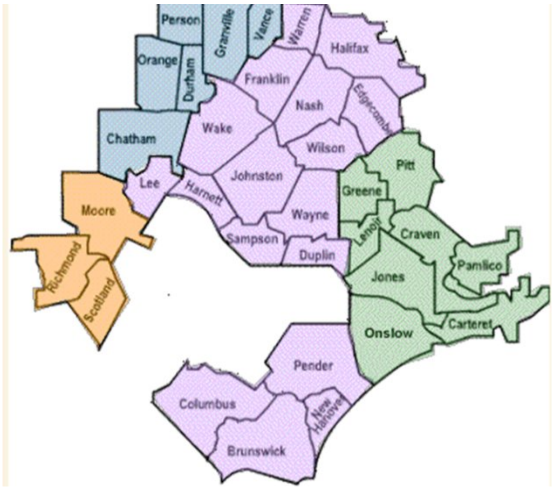
This greenhouse gas emissions inventory was conducted specifically for FBCENC's Raleigh Branch for FY 2011-2012. The food banks' fiscal year is 1 July to 30 June.

Overview of Food Bank's Operations

FBCENC consists of 6 separate branches servicing 34 counties, each with its own warehouse and trucking resources. The sizes of each of the warehouses are as follows:

a. Raleigh (40,000 sqft)
b. Greenville (23,000 sqft)
c. Durham (18,000 sqft)
d. Sandhills (11,000 sqft)
e. Wilmington (8,000 sqft)
f. New Bern (6,5000 sqft)

Figure 1 - North Carolina counties served by FBCENC, 2013



Source: FBCENC Website: http://www.foodbankcenc.org/site/PageServer?pagename=hunger_counties

Of all the warehouses, the Raleigh Branch facility is the only one that FBCENC owns[74].

The FBCENC fleet consists of 2 tractors 5 trailers and 15 refrigerated box trucks. FBCENC relies on many corporate and individual volunteers to assist in their operations. They have 13,000 volunteers who contribute about 157,000 hours of volunteer time each year to help in various aspects of food packaging, delivery and office administration[75].

The Raleigh Branch of the FBCENC serves 13 out of the 34 counties that FBCENC covers. The 13 counties covered are: Duplin, Franklin, Halifax, Harnett, Johnston, Nash, Sampson, Wake, Warren, Wayne, Edgecombe, Lee and Wilson. Edgecombe and Wilson counties are shared with the Greenville Branch, and Lee county is shared with the Sandhills Branch.

The Raleigh Branch facility is located at 3808 Tarheel Drive, Raleigh, NC 27609. This 1969 site consists of the main building which houses a 5,000sqft office facility and 38,000sqft of warehousing space[76]. This includes 3,500sqft of refrigerated space[77]. Aside from being a branch in the FBCENC network, it also acts as a regional distribution warehouse.

During FY 2011-2012, the Raleigh Branch distributed 24.5 million pounds of food, of which 10.1 million pounds was dry goods, 8.9 million pounds fresh produce, and 5.6 million pounds other frozen and refrigerated goods. The Raleigh branch operates 2 tractor-trailers and 5 box trucks and the fleet travelled a total of 322,114 miles[78] in FY 2011-2012.

Current Sustainability Measures Taken

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[74] Interview with staff of Operations Department on 31 May 2013.
[75] Interview with staff of Operations Department on 31 May 2013.
[76] FBCENC data provided by Operations Department on 31 May 2013.
[77] Clear Energy. (2010). *Energy Conservation Measures Report and Proposal – Food Bank of Central and Eastern NC*.
[78] FBCENC data provided by Operations Department on 31 May 2013.

FBCENC participated in a grant program sponsored by Walmart that enabled the Raleigh Branch to add motion sensors to its lighting and programmable thermostats for the office HVAC. Based on an energy conservation audit conducted in 2010, this retrofit is projected to save 245, 565kWh of energy annually.

Methodology

The calculation methods used for the GHG emissions inventory follows the recommendations of the General Reporting Protocol for the Voluntary Reporting Program (Version 1.1) (GRP) published by The Climate Registry in 2008.The inventory is calculated at a facility level. Because of the difficulty to do actual emissions monitoring, emissions quantification are largely Tier B and Tier C methods. Appendix A details the different tiers used in this inventory as well as the relevant emissions factors used in calculation.

Organizational and Operational Boundaries

This greenhouse gas emissions inventory includes the owned facility at the Raleigh branch of FBCENC and owned/leased fleet vehicles used in the operations of the facility at the Raleigh branch. Although, transportation provided by other partners and agencies are an important part of the delivery mechanism of the food bank[79], it is difficult to obtain trucking information from all the partners that can be attributed only to activity related to this food bank's activities. Further, these transportation emissions are beyond the control of the food bank. Hence, any vehicles used by partner agencies, donors, other suppliers to provide to the operations of the facility at the Raleigh branch are not covered in this inventory.

A smaller source of transportation emissions is related to employee travel. While the food bank currently has 90 employees, it has a much larger number of volunteers. Volunteer groups are at the food bank almost daily and the food bank's operations are highly reliant on the help of the volunteers provide. However, the assumption is that their commute to the food bank on the volunteer days is in replacement of their commute to work and hence it is omitted in the analysis.

The following greenhouse gases are included in this inventory: Carbon Dioxide, Methane, Nitrous Oxide, Hydrofluorocarbons (HFCs).

GHG Emissions Scopes

Scope 1: Direct Emissions

For this greenhouse gas inventory, the direct emissions included are:

- Stationary combustion of natural gas to produce heat and hot water using equipment in a fixed location.
- Mobile combustion of fuels in fleet transportation sources such as trucks used. The fleet operates on diesel fuel only.

[79] Based on data provided by the Raleigh branch for March 2013, roughly 36% of the food delivered is provided through agencies and partners coming to the warehouse to shop for the desired food products.

- Fugitive emissions that are unintentional releases from refrigeration.

Scope 2: Indirect Emissions

Scope 2 refers to indirect emissions associated with the consumption of purchased electricity. For this greenhouse gas inventory, the indirect emissions included are:

Purchased Electricity

Scope 3: Other Indirect Emissions

Scope 3 emissions include all other indirect emissions not covered in Scope 2. Because the food bank does not engage in any manufacturing, the key areas expected to contribute significantly to its Scope 3 emissions are in transport-related activities in vehicles not owned or controlled by the food bank and its own waste disposal.

As mentioned before, because of the difficulty in obtaining mileage and fuel use data pertaining solely to FBCENC's activities of vehicles that are not owned or controlled by FBCENC, this is considered outside the operational boundary of this inventory. For this greenhouse gas inventory, the Scope 3 emissions included:

- Waste Disposal of FBCENC

Downstream waste disposal by consumers of the food bank is not included in this inventory. In terms of social impact, the food bank estimates that the food they provide only meets 8-10% of the food needs of food insecure population in the region of service[80]. Hence, the food bank reasonably assumes that the food they provide is fully consumed.

Greenhouse Gas Emissions Inventory

The summary of the estimated greenhouse gas emissions is provided in Table 1. A total of 1,733 $mTCO_2e$ is emitted for the 24.5 million pounds of food delivered by FBCENC's Raleigh branch. Every million pound of food delivered has a GHG footprint of 72 $mTCO_2e$.

Table 1 – Greenhouse Gas Emissions, Fiscal Year 2011-2012

[80] Interview with staff of Operations Department on 31 May 2013.

Emissions Type	CO_2e (Metric Tons)	% of reported emissions
Scope 1: Direct		
Vehicle fuel combustion (100% diesel)	632	36.4%
Natural gas for heating	28	1.6%
Refrigerant leakage in facilities	169	9.7%
Refrigerant leakage in vehicles[a]	67	3.8%
Scope 2: Indirect		
Purchased Electricity	257	14.8%
Scope 3: Other indirect		
Waste[b]	581	33.5%
Total emissions	1,734	

[a] Using the screening method allowed in The Climate Registry's calculation methods, refrigeration emissions from the 5 refrigerated trailer units used by Raleigh branch is less than 5% of total emissions and hence the higher of the screening method estimates are used. For estimation details, please see Appendix 6B.

[b] The food bank generated 1.6million lbs of waste in FY 2011-2012. Less than 50% of this waste is food that was received but could not be distributed. While not all the waste is food scraps, the GHG emissions were modelled as if all the waste were food scraps as no waste audit was conducted on site. This will likely result in a higher amount of GHG emissions from waste.

Details of emissions

In all calculations for the greenhouse gas inventory, emissions from CO_2 and where possible and significant, CH_4 and N_20 are accounted for.

Table 2 – Scope 1 Emissions Details

Scope 1 Emissions Details

	CO_2	Others (CH_4+N_2O+HFC)
Fuel Summary in $mTCO_2e$	631	1
Natural Gas Summary in mTCO2e	28	
Refrigerant leakage in facilities in $mTCO_2e$		169
Refrigerant leakage in vehicles[a] in $mTCO_2e$		67

[a] Using the screening method allowed in The Climate Registry's calculation methods, refrigeration emissions from the 5 refrigerated trailer units used by Raleigh branch is less than 5% of total emissions and hence the higher of the screening method estimates are used. For estimation details, please see Appendix 6B.

Scope 1 emissions from vehicle fuel combustion includes both the CO_2 emissions from the 71,600 gallons of diesel fuel used, as well as estimates of CH_4 and N_20 emissions from the 322,000 miles travelled by the fleet. The estimates are based on the default emission factors for CH_4 and N_20 emissions of highway heavy duty diesel trucks provided in the GRP.

Scope 1 emissions from natural gas used for heating the facility is calculated based on usage obtained through utility bills (5,185 Therms). Using the standard emissions factor provided in the GRP, CO_2 emissions are calculated. CH_4 and N_20 emissions have been excluded because they are much smaller in order of magnitude.

Scope 1 emissions from refrigerant usage is calculated based on purchase of new refrigerants to service the existing equipment within the branch. A total of 150lbs of refrigerant recharge was purchased, and while this occurred within the last 2 years, no other recharge had been purchased in at least 5 years. The main freezer and refrigeration units are located on the rooftops. The refrigerant used at FBCENC Raleigh branch is assumed to be a mix of R-22 and R-404A based on visible evidence of the accessible refrigeration units at the front of the branch.

Emissions from refrigerated trucking were estimated using GRP's Screening Method and default emission factors provided. The estimation concluded that the emissions from refrigerated transport are less than 5% of total emissions by the Raleigh branch. Hence, the Screening Method's estimates were used.

Table 3 – Scope 2 emissions details

Scope 2 Emissions Details

	CO_2	Others (CH_4+N_2O)
Purchased Electricity Summary in $mTCO_2e$	256	1

Scope 2 emissions from purchased electricity include CO_2 emissions as well as CH_4 and N_2O emissions. Both are calculated based on the emissions factors obtained with EPA's eGRID subregion and GHG emissions finder tool (Version 4.1) published 3/1/2013[81]. The total electricity purchased was obtained through utility bills (544,760 kWh).

Table 4 – Scope 3 emissions details

Scope 3 Emissions Details

	CO_2	Others (CH_4+N_2O)
Waste Summary in $mTCO_2e$		581

Scope 3 emissions from waste are based on the CO_2e emissions from EPA's WARM model (Version 12) published online February 2012. The model calculates emissions from decomposition of different materials placed in landfills. This calculation also includes an estimate of the transportation emissions. The food bank generated 1.6 million pounds of waste in FY 2011-2012. Less than 50% of this waste is food that was received but could not be distributed. While not all the waste is food scraps, the GHG emissions were modelled as if all the waste were food scraps as no waste audit was conducted on site. This will likely result in a higher calculated amount of GHG emissions than the actual emissions.

[81] EPA eGrid Power Profiler Zip Code Tool v4.1 (Mar 2013) available at: http://www.epa.gov/cleanenergy/documents/egridzips/Power_Profiler_Zipcode_Tool_v4-1.xlsx

Appendix 6A: Emissions quantification tiers and emission factors

Emission Source Type	Data Quality Tier	Method	Emission Factors[82]
Scope 1: Direct Emissions from Stationary Combustion	Tier C	Calculation Based on Fuel Use	Natural Gas Emission Factor: 0.054 kg CO_2/scf
Scope 1: Direct Emissions from Mobile Combustion	Tier B for CO_2 Tier B for CH_4 and N_2O	Fuel Use for CO_2 Miles travelled by vehicle type for CH_4 and N_2O	Diesel Emission Factor: 8.81 kg CO_2/gal 0.0048 g CH_4 /mil 0.0051 g N_2O /mil
Scope 1: Direct Fugitive Emissions from Use of Refrigeration and Air Conditioning Equipment	Tier B	Simplified mass balance approach	Global Warming Potential (GWP): R22 – 1810 per metric ton refrigerant[83] R404A – 3260 per metric ton refrigerant
Scope 2: Indirect Emissions from Electricity Use	Tier B	Known electricity use from utility bills	eGRID power pool-specific factor for zipcode 27609: 1035.869 lb CO_2/MWh 0.0215 lb CH_4/MWh 0.0174 lb N_2O /MWh
Scope 3:Indirect Emissions from Waste	No GRP methodology provided, EPA's WARM model used		Average emission factor for food scraps in landfill: 0.69 $mTCO_2e$/ton of food

[82] In order to obtain CO_2 equivalents of CH_4 and N_2O emissions, the respective global warming potentials (GWP) are applied. CH_4's GWP = 21 and N_2O's GWP = 310.

[83] The R-22 refrigerant's GWP was not available in the GRP document. GWP for R-22 obtained from EPA's Factsheet: *Transitioning to Low-GWP Alternatives in Commercial Refrigeration* (Publication No: EPA-430-F-10-043) issued in October 2010.

Appendix 6B: Scope 1 emissions calculation methodology

The Scope 1 emissions included in this GHG inventory are:

a. Direct Emissions from Stationary Combustion from Natural Gas for Heating
b. Direct Emissions from Mobile Combustion from Transportation
c. Direct Fugitive Emissions from Use of Refrigeration in Warehouse
d. Direct Fugitive Emissions from Use of Refrigeration in Mobile Transportation

<u>Calculation for Direct Emissions from Station Combusting from Natural Gas for Heating</u>

Estimation was based on actual use of natural gas provided through utility bills in Therms and default emission factors.

Total Natural Gas usage FY 2011-2012 = 5,185 Therms (equivalent to 518,500 scf or 1,410,008.9 Btu)

CO_2 for Natural Gas	CH_4 for Natural Gas	N_2O for Natural Gas
0.054 kg/scf	1g/MMBtu	0.1g/MMBtu
GWP = 1	GWP = 21	GWP = 310

GHG Emissions =

$$\textit{Natural Gas usage in scf} * \textit{Emission factor for } CO_2 * (1/1{,}000) +$$

$$\textit{Natural Gas usage in MMBtu} * \textit{Emission factor for } CH_4 * GWP_{CH4} * (1/1{,}000{,}000) +$$

$$\textit{Natural Gas usage in MMBtu} * \textit{Emission factor for } N_2O * GWP_{N2O} * (1/1{,}000{,}000)$$

<u>Calculation for Direct Emissions from Mobile Combustion from Transportation</u>

Estimation was based on actual use data but with default emission factors. All the trucks that FBCENC Raleigh branch uses run on diesel. All trucks are considered to be heavy duty highway vehicles. However, the actual control technology in the vehicles were not determined to calculate CH_4 and N_20 emissions, and hence default emissions were used[84].

Total diesel used = 71,644 gallons (includes fuel used to run refrigeration units)

Total mileage travelled by fleet = 322,114miles

Emission factors:

[84] As provided in Table 13.4 in The Climate Registry's General Reporting Protocol, Version 1.1.

CO_2 for Diesel	CH_4 for Heavy Duty Vehicles	N_2O for Heavy Duty Vehicles
8.81 kg CO_2/gal	0.0048 gCH_4/mile	0.0051 gN_2O/mile

GHG Emissions:

*(Diesel used * CO_2 Emission Factor for Diesel * GWP) *(1/1,000)* +

*(Mileage travelled * CH_4 Emission Factor for Heavy Duty Vehicles * GWP_{CH4}) *(1/1,000,000)* +

*(Mileage travelled * N_2O Emission Factor for Heavy Duty Vehicles * GWP_{N2O}) *(1/1,000,000)*

Calculation for Direct Fugitive Emissions from Use of Refrigeration in warehouse

The simplified mass balance approach was used. The quantity of refrigerant used to service existing equipment was available. No new equipment was purchased and no equipment was retired. The specific type of refrigerant purchased for servicing not available and was assumed to be an equal mix of R-22 and R404A based on visual inspection of refrigerating equipment.

Quantity of refrigerant used to service equipment = 150lbs

Emission factors:

R22	R404A
GWP = 1,810	GWP = 3,260

GHG Emissions =

*Quantity of refrigerant used to service equipment in metric ton * (GWP_{R22} + GWP_{R404A})/2*

Calculation for Direct Fugitive Emissions from Use of Refrigeration in Mobile Transportation

No exact data was available to calculate the emissions. Instead, the GRP's Screening Method was used to determine if these emissions were below the threshold of 5 percent of total entity-wide emissions. To estimate the quantity, the following default emission factors were used. Where a range was provided for defaults, the upper limit was used:

Capacity of existing equipment for transport refrigeration = 8kg

Operation emission factor = 50%

Time in years of use = 1

GHG Emissions estimated by Screening Method =

Capacity of existing equipment in metric ton x operation emissions factor x time in use x no. of refrigerated transport x GWP of refrigerant used x no. of units in use

For this calculation, the refrigerant used is assumed to be R507A. R507A is listed as one of the most commonly used refrigerant in transport refrigerant since the 1990s[85]. Out of the 5 refrigerants listed, R507A has the highest GWP of 3,300. FBCENC Raleigh branch operated a total of 5 refrigerated transport units.

GHG emissions calculated of 67 $mTCO_2e$ is less than 5% of total emissions (87 $mTCO_2e$). Hence, the screening method estimation was used.

[85] United States Environmental Protection Agency. (2011). *Transitioning to Low-GWP Alternatives in Transport Refrigeration* (Publication No: EPA-430-F-11-064). Washington, DC: U.S. Government Printing Office.

Appendix 6C: Scope 2 emissions calculation methodology

The only Scope 2 emissions included in this GHG inventory is the indirect emissions from electricity use.

Calculation for Indirect Emissions from Electrical Use

Electricity usage was known and available in the form of monthly utility bills but generator-specific emission factors was unavailable, eGRID power pool-specific factors were used.

For this GHG inventory, the parameters used were as follows:

Total electrical use FY 2011-2012: 544,760kWh

Emission factors for zipcode = 27609

CO_2	CH_4	N_2O
1035.869 lb CO_2/MWh	0.0215 lb CH_4/MWh	0.0174 lb N_2O /MWh

GHG Emissions =

*Electrical Usage in MWh * 1035.869 lb CO_2/MWh * (1/2,204.62) lbs/metric ton +*

*Electrical Usage in MWh * 0.0215 lb CH_4/MWh * (1/2,204.62) lbs/metric ton * GWP_{CH4} +*

*Electrical Usage in MWh * 0.0174 lb N_2O /MWh * (1/2,204.62) lbs/metric ton * GWP_{N2O}*

Appendix 6D: Scope 3 emissions calculation methodology

As GRP did not have provide a calculation methodology for emissions from waste produced, EPA's WARM model version 12 (Feb 2012) was used to estimate the emissions from the waste FBCENC's Raleigh branch generated. The WARM model used is available as an online form here: http://epa.gov/epawaste/conserve/tools/warm/Warm_Form.html

It is important to note that the WARM model emission factors calculate the CO_2e emissions that occur on top of the biogenic CO_2 that would have occurred. It includes[86]:

1. CH_4 emissions from anaerobic decomposition of biogenic carbon compounds (as CH_4 emissions would not have occurred if not for deposition in landfills);
2. Biogenic carbon stored in the landfill;
3. Transportation CO_2 emissions from landfilling equipment;
4. CO_2 emissions avoided through landfill gas-to-energy projects.

2 key assumptions users have to make in the WARM's calculation of GHG emissions is whether a landfill has landfill gas recovery in place and the distance that will be travelled by the waste to the landfill. I assume the distance travelled to landfill is the default (20 miles). According to EPA's Landfill Methane Outreach Program, there are 23 landfills in North Carolina that have operational landfill gas recovery systems[87]. That is less than 15% of the 161 active landfills that the North Carolinas Department of Environment and Natural Resources has on record. As a best estimate, the WARM model is set to calculate landfill gas recovery at national averages.

For this GHG Inventory, the online WARM form was used with the following parameters:

Food scraps landfilled: 841 short tons (1,682,723 lbs)[88]

Transportation to landfill: Default option provided

Landfill Gas Recovery: National Average used.

EPA WARM emission factor for food scraps = 0.69.

GHG Emissions = Amount of food scraps x emission factor.

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[86] United States Environmental Protection Agency. (2012). *WARM Version 12, Landfilling Documentation*, retrieved from: http://epa.gov/epawaste/conserve/tools/warm/pdfs/Landfilling.pdf

[87] United States Environmental Protection Agencey. (2012). [Map illustration of landfill gas projects across United States]. *Landfill Methane Outreach Program*. Retrieved 28 June 2012 from: http://www.epa.gov/lmop/projects-candidates/index.html

[88] FBCENC data provided by Operations Department on 31 May 2013. The food bank generated 1.6million pounds of waste in FY 2011-2012. Less than 50% of this waste is food that was received but could not be distributed. While not all the waste is food scraps, the GHG emissions were modelled as if all the waste were food scraps as no waste audit was conducted on site. This will likely result in a higher calculated amount of GHG emissions than the actual emissions.

Appendix 6E: Feeding America's food waste diversion estimation

Feeding America's methodology is based on the 5 channel of their food banks receive food from[89]:

a. Federal commodities: 0% diversion
b. Manufactured foods: 100% diversion
c. Purchasing: 0% diversion
d. Produce: 50% diversion
e. Retail: 100% landfill diversion

[89] Interview with staff of Supply Chain Group, Feeding America.

Appendix 7 – GIS methods for calculating distance travelled to landfill

LandfillDist Analysis

Purpose of analysis: To determine the distance between suppliers of food bank to nearest landfill. This will be compared to the total distance the food bank's fleet travels to pickup and deliver the food provided by suppliers.

1. Data Sources

a. 2 weeks (Mar 2 – Mar 15 2013) of trucking pickup and dropoff locations provided by food bank.
b. ESRI shapefile of Active Permitted (AP) landfill locations from North Carolina Department of Environment and Natural Resources website, published 24 Jan 2011: http://portal.ncdenr.org/web/wm/gis/data
c. Geodatabase format of Road Characteristics for North Carolina from North Carolina Department Of Transportation website: https://connect.ncdot.gov/resources/gis/pages/gis-data-layers.aspx. The Geodatabase includes a Road Network dataset (NCDOT_Roads) which will be with the Network Analyst tool.

2. Data Preparation

A list of the stops that the food bank trucks from was obtained for the 2-week period (Mar 2 – Mar 15). The food bank repeats its trucking schedule every 2 weeks, hence this is a representative sample of pickup and deliveries it will do throughout the year.

The data provided by the food bank included –

Date of Travel – Date for each travel manifest provided. FBCENC Raleigh branch trucks Monday – Saturday .

Trucking Equipment ID – Each of the 7 trucks that FBCENC Raleigh branch uses has a specific ID.

Odometer Out – Odometer readings when trucks leave the Raleigh branch on their first trip are provided per truck per day.

Odometer In – Odometer readings when the trucks return to Raleigh branch after their last trip are provided per truck per day.

Stop Name – Name of the donor for pickup or partner agency for delivery.

Stop Address – Address of the donor for pickup or partner agency for delivery. Address provided includes Street, City and Zip.

Stop Type – Identifies if the stop is a donor, a partner agency or another branch.

The list of addresses for donors (suppliers of food banks) were extracted and the addresses were uploaded in MS Access as a *.mdb file.

ArcGIS mapping preparation done:

Workspace environment factors were set to the Extent and Projection based on the AP Landfill shapefile. As the projection and coordinate system used for both the data file are similar, no projection was done.

Data File	Current Coordinate System/Projection
AP Landfill shapefile	NAD_1983_StatePlane_North_Carolina_FIPS_3200
NC DOT Road Network feature class	NAD_1983_StatePlane_North_Carolina_FIPS_3200

3. Geocoding Addresses

The MS Access table "DonorOnly" is loaded to ArcMap as Address Input Table. The "Geocode Address" Tool is used by right-clicking on the loaded Table.

Address Locator used is World Geocode Service (an ArcGIS Online service)

Address Input Fields Used:

World Geocode Service Fields	Address Input Table Fields
Address	Street
City	City
Region	State
Postal	Zip

Geocoding resulted in 88% matched results, with 35 address entries unmatched.

Geocoding results were amended with manual editing of these 35 addresses using googlemaps to obtain the required XY coordinates. Amended results used for Closest Facility analysis.

4. Closest Facility

AP Landfill shapefile points loaded as Facilities. There are 161 landfill locations loaded. Search tolerance set to 5000m.

Geocoded addresses were loaded as Incidents. There are 347 Incidents locations loaded. Search tolerance set to 5000m.

Solving for Closest Facility resulted in 18 Unsolved Incidents. All unsolved incidents came from 5 locations. A list of unsolved locations are provided.

Closest Facility Route table exported as a *.dbf file that can be accessed by Excel.

5. Comparing trucking to nearest landfill to actual trucking mileage

Excel used to calculate the total travel route length from each donor (Incident) to their nearest landfill (Facility) for the time period Mar2 – Mar 15.

Excel used to calculate the total travel of FBCENC trucks between Mar 2 – Mar 15 based on odometer readings provided.

Calculated that the trucking to the nearest landfill is 18% the total trucking the food bank had to perform to pickup and deliver the food to its partner agencies.

<u>List of unsolved Closest Facility locations</u>

5 locations contribute to 18 Unsolved Incidents (out of 347 Incidents)

List of unsolved incidents:

Warning: No "Facilities" found for "Walmart Supercenter #2058" in "Incidents".

Warning: No "Facilities" found for "Food lion #1484" in "Incidents".

Warning: No "Facilities" found for "Food Lion #1484" in "Incidents".

Warning: No "Facilities" found for "Food lion #1669" in "Incidents".

Warning: No "Facilities" found for "Walmart supercenter #2508" in "Incidents".

Warning: No "Facilities" found for "NCSU/McKimmon Center" in "Incidents".

Warning: No "Facilities" found for "Food Lion #1484" in "Incidents".

Warning: No "Facilities" found for "Target - Rocky Mount" in "Incidents".

Warning: No "Facilities" found for "walmart supercenter #2058" in "Incidents".

Warning: No "Facilities" found for "walmart supercenter #2508" in "Incidents".

Warning: No "Facilities" found for "Food lion #1484" in "Incidents".

Warning: No "Facilities" found for "walmart supercenter #2058" in "Incidents".

Warning: No "Facilities" found for "Food lion #1484" in "Incidents".

Warning: No "Facilities" found for "Food Lion #1669" in "Incidents".

Warning: No "Facilities" found for "Target - Rocky Mount" in "Incidents".

Warning: No "Facilities" found for "walmart supercenter #2058" in "Incidents".

Warning: No "Facilities" found for "Food Lion #1484" in "Incidents".

Warning: No "Facilities" found for "Food Lion #1669" in "Incidents".

Appendix 8 – Calculating the carbon footprint of each pound of food

Understanding how the food type and mode of delivery contributes to the total GHG emissions of the food bank will help to understand the future trend of GHG emissions as the food bank grows to achieve its mission of providing food (and better nutrition) to the food insecure.

A very high level analysis is conducted, based on the data provided describing:

(1) Amount of food delivered that requires some form of refrigeration. This includes fresh produce, refrigerated food and frozen food, and;
(2) Amount of food that is transported by the food bank's own trucks versus other forms of transport.

<u>Analysis of GHG Emissions from Transportation</u>

March data from FBCENC's Raleigh branch shows that 13% of the food it delivers is picked up directly by partner agencies from suppliers, for example Food Lion. Out of the 21.3 million pounds that is transported by the food bank to its branch/warehouse, another 36% gets picked up by partner agencies.

The GHG Emissions from transportation is evenly distributed between the incoming phase and outgoing phase. As each truck dispatched from the Raleigh branch can pickup as well as deliver, depending on the best route for the day, it is impossible to have a more accurate breakdown of the emissions.

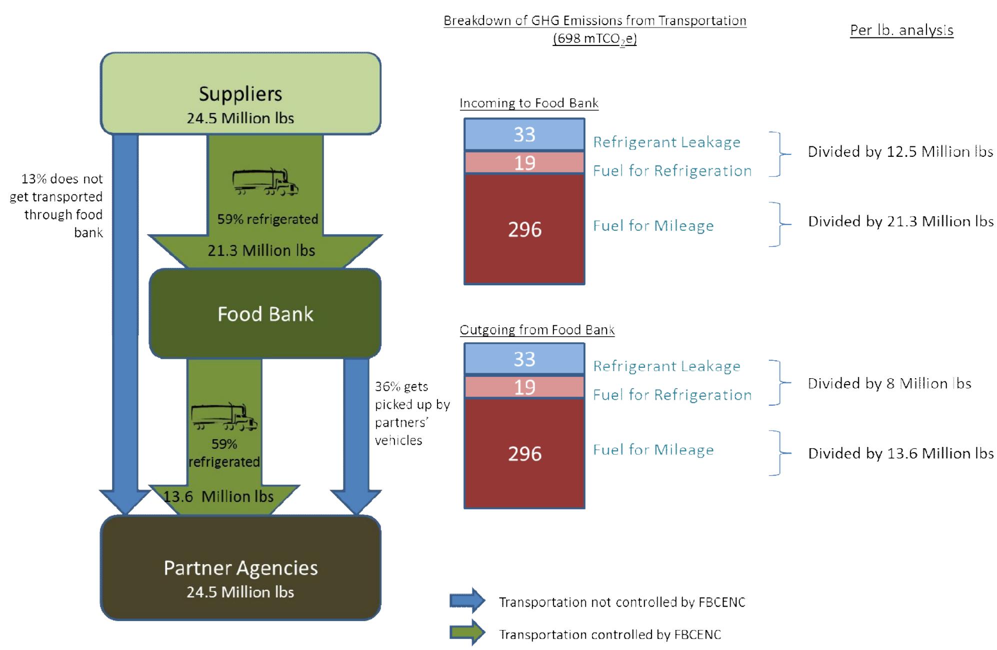

Figure 1: High level breakdown of GHG emissions from transport of food to and from food bank

Using this high level break down, I calculate 4 modes of delivery scenarios:

1) A pound of food that needs refrigeration and is trucked both into and out of the food bank.
2) A pound of food that does not need refrigeration and is trucked both into and out of the food bank.
3) A pound of food that needs refrigeration and is only trucked into the food bank.
4) A pound of food that does not need refrigeration and is only trucked into the food bank.

Transportation Emission per lb of food delivered		
Basic average, every pound of food produces GHG from transport	0.072	lb CO2e
If you were a pound of food that needs refrigerated transport and trucked in/out	0.102	lb CO2e
If you were a pound of food that does not need refrigerated transport but trucked in/out	0.079	lb CO2e
If you were a pound of food that needs refrigerated transport and trucked in only	0.040	lb CO2e
If you were a pound of food that does not need refrigerated transport and trucked in only	0.031	lb CO2e

Table 1: Per pound analysis of transportation emissions.

The analysis outcome shows that having to refrigerate food during transport emits 1.3 times more GHG than food that does not need to be refrigerated. It also highlights the importance of trucking efficiency to the GHG footprint of the food. Food that is trucked both into and out of the food bank emits 2.6 times more GHG than food that is just trucked into the food bank.

Analysis of GHG Emissions from Warehousing

Information on the square footage of space dedicated to warehousing and office were obtained, as well as the size of the refrigeration units at FBCENC Raleigh branch.

FBCENC has a freezer that is 50,000 ft^3 and a refrigerator/chiller that is 8,400 ft^3. Based on these sizes, the total electrical use for refrigeration is estimated based on a California survey on warehousing energy use.[90] The study estimated the energy use of warehouse refrigeration to be:

Specific energy consumption (SEC) in = 38.978 (storage volume)$^{-0.2275}$ kWh per year per cubic foot

Using the equation, the refrigeration energy consumption FY 2011-2012 is calculated to be 208,165kWh, or 38% of the total electrical energy used at FBCENC Raleigh branch. The remaining electrical use is distributed between the warehouse and office by square footage. Natural gas usage is also distributed between the warehouse and office by square footage. The warehouse takes up 38,000sq ft, while the office spaces take up 5,000 sq ft.

[90] Singh, R. Paul. 2008. Benchmarking Study of the Refrigerated Warehousing Industry Sector in California. Public Interest Energy Research (PIER) Program Contract and Research Project Reports. California Energy Commission, PIER Program.

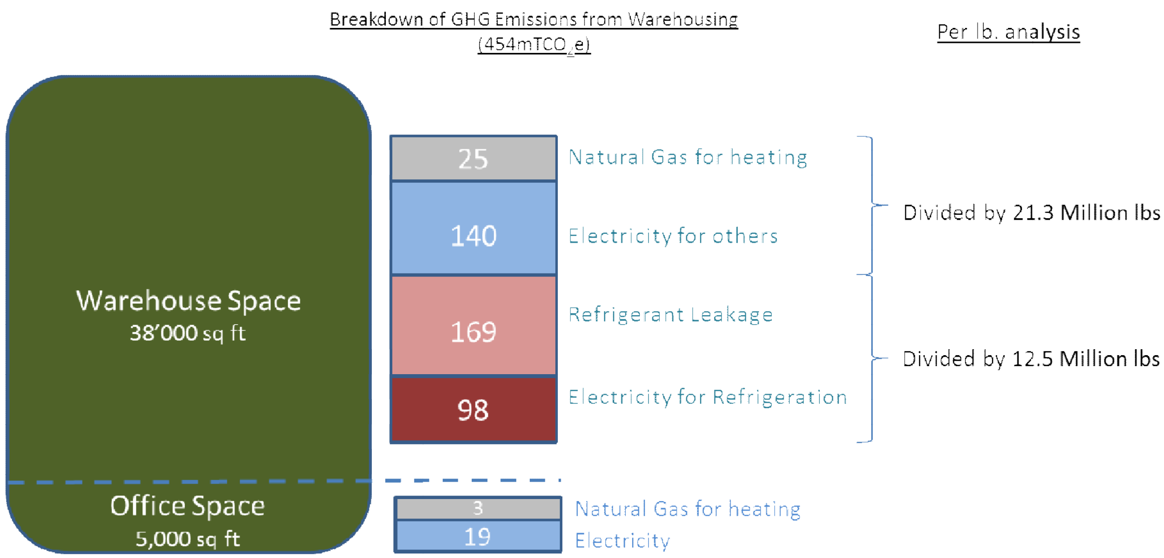

Figure 2: High level breakdown of GHG emissions from warehousing food in food bank

Using this high level breakdown, 2 scenarios of food types were analyzed:

1) Food that needs to be refrigerated.
2) Food that does not need to be refrigerated.

Warehousing Emission per lb of food delivered	
Basic average, every pound of food produces GHG from warehousing	0.045 lb CO2e
If you were a pound of food that needs refrigeration	0.064 lb CO2e
If you were a pound of food that does not need refrigeration	0.017 lb CO2e

Table 2: Per pound analysis of warehousing emissions.

The analysis outcome shows that having to refrigerate food during warehousing emits 3.8 times more Warehouse GHG than food that does not need to be refrigerated.

Appendix 9 – Calculating the impact of monetization of carbon offsets

To analyze the impact of monetization, the amount that can be raised by the food bank through its GHG savings is compared to various items to establish – financial impact, mission impact and impact on asset enhancements that can help it advance its mission.

		Price of carbon in voluntary market	
		$7/ton[9]	$10/ton
Amount that can be raised from carbon offset		$30,511	$43,588
	Actual	%	%
Financial Impact			
Annual Budget (FY 2012-2013)[1]	$7,480,000	0.4%	0.6%
Cash Contributions (FY 2011 - 2012)[2]	$9,091,890	0.3%	0.5%
Mission Impact			
No. of meals thatcan be purchased[3]	@ $2.67/meal	11,427	16,325
No. of hungry people in NC[4]	1,863,330	1%	1%
Asset Enhancement Impact			
Full time employee average wage[5]	$31,977	95%	136%
Cost of lighting/control energy efficiency upgrade[6]	$46,116	66%	95%
Cost of additional refrigerated trailer+cab[7]	$77,000	40%	57%
Cost of solar panel installation for 20% energy[8]	$261,000	12%	17%

Long term impact of asset enhancements	Financial		Environmental	
	Annual	10-Year	Annual	% of current emissions
Annual energy savings - lighting/control upgrade	$13,850	$138,500		
Annual energy savings - solar energy	$10,786	$107,860		
Annual CO_2e savings - lighting/control upgrade			91.25 mTCO2e	5%
Annual CO_2e savings - solar energy			51.48 mtCO2e	3%

[1] Annual budget for all six branches of FBCENC for FY 2012-2013 was used as FY2011-2012 no longer available on FBCENC website, Mission and Goals, retrieved 29 Nov 2013: http://www.foodbankcenc.org/site/PageServer?pagename=about_mission .

[2] Cash contributions calculated from FBCENC's Form 990 (FY 2011) from Guidestar.

[3] Cost per meal used is national average as provided by Feeding America's Map the Meal Gap study, retrieved on 29 Nov 2013: http://feedingamerica.org/hunger-in-america/hunger-studies/map-the-meal-gap.aspx .

[4] Statistic on hunger obtained from Map the Meal Gap state by state study conducted by Feeding America for 2011, obtained from Feeding America website, retrieved 29 Nov 2013: http://feedingamerica.org/hunger-in-america/hunger-studies/map-the-meal-gap.aspx .

[5] Average employee wage calculated from FBCENC's Form 990 (FY 2011) from Guidestar.

[6] Cost of lighting/controls energy efficiency upgrade and corresponding savings were obtained from Clear Energy's "Audit of Energy Conservation Measures for FBCENC" conducted in 2010. The upgrades were completed with a grant from Walmart.

[7] Cost of used refrigerated trailer and tractor estimated from available used trucks in FBCENC's zipcode and within 5 years of use. Data obtained from Ryder's Used Truck Inventory, retrieved 29 Nov 2013: http://www.usedtrucks.ryder.com/vehicle/VehicleSearch.aspx?VehicleTypeId=3&VehicleGroupId=12 .

[8] Cost of solar panelling and corresponding savings obtained from free online solar estimator. Calculations are post federal and state subsidies. Website used on 29 Nov 2013: http://www.solar-estimate.org/ .

[9] Price of carbon in voluntary markets obtained from Ecosystem Marketplace and Bloomberg New Energy Finance's annual report "State of Voluntary Carbon Markets 2013: Maneuvering the Mosaic". Overall traded price for voluntary credits worldwide was $5.9/tCO_2e$. However, for credits generated by non-profits, the average price was $6.8/tCO_2e$.

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